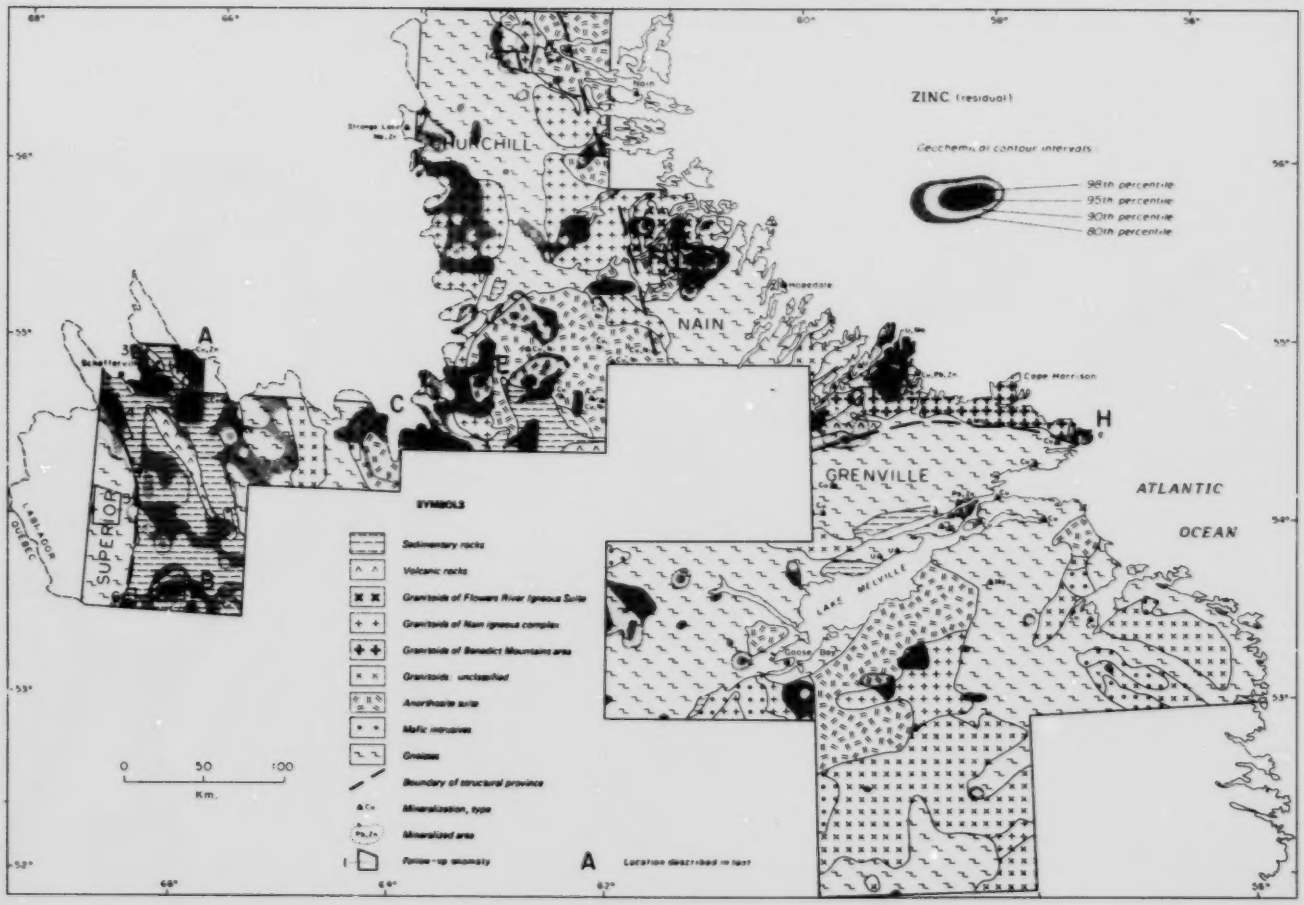
Mineral Development Division
Department of Mines and Energy
Government of Newfoundland and Labrador

RECONNAISSANCE AND DETAILED GEOCHEMICAL SURVEYS FOR BASE METALS IN LABRADOR

by

John McConnell

Report 84-2



St. John's, Newfoundland

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The cover illustration is of the distribution of residual zinc in lake sediments in Labrador, compiled from data from the reconnaissance survey.

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ABSTRACT

A reconnaissance lake sediment and water survey, funded jointly by the governments of Canada and Newfoundland, was conducted over an area of 134,000 km^2 representing approximately 50% of Labrador. Analytical data obtained from the 8048 sample sites were released previously in the form of 1:250,000 scale maps of element distributions and as summary statistics. Here, these data are summarized into a smaller aggregated data set by establishing, for the whole survey area, a grid of 1386 cells each 10 km on a side, and calculating the means, standard deviations and ranges for the sample data within each cell. Using this aggregated data set, relationships among the various chemical and physical variables are examined and nongeological environmental factors which affect the chemical composition of lake sediment are identified. In particular, lake depth at the sample site and iron content of sediment correlate strongly with concentration of several trace elements including copper, nickel, zinc, molybdenum and manganese. Regression analysis is used to remove the effects of depth and Fe. Maps of the geochemical dispersion patterns of both the residual and raw data reveal several areas with elevated trace element concentrations. In areas which have received exploration attention such as the Central Mineral Belt and the Labrador Trough, many of these anomalies correlate with known mineralization or can be explained in terms of bedrock composition; too little is known about the geology of others to do more than speculate as to their cause (e.g. Cu-Ni anomalies in northern Churchill Province, Zn anomalies in southern Churchill Province, etc.).

Detailed lake sediment/water surveys conducted over nine anomalous areas within the reconnaissance survey confirmed the regional scale anomalies and provided a focus for ground follow-up work on five of them. Base metal mineralization was found at Anomalies 5 and 8. Stream sediment/water surveys and soil surveys successfully delineated an as yet unexplained Zn anomaly in the Labrador Trough (Anomaly 3). A soil survey at Anomaly 8 failed to explain a lake sediment/water anomaly and underscores the need, in this region, to evaluate the Quaternary geology at a detailed level prior to sampling.

In general, lake sediment/lake water sampling in Labrador is an effective method of outlining areas underlain by bedrock enriched in base metals. Such areas are commonly mineralized. Stream sediment, stream water and soils are effective sampling media for exploration at the detailed scale, but due regard must be paid to the local glacial history.

CHAPTER 1

INTRODUCTION

Objectives

Historically, base metal exploration in Labrador has focused on two areas, the Central Mineral Belt and the Labrador Trough. Other areas have received little or no attention. During the summers of 1977 and 1978, under the Canada-Newfoundland Uranium Reconnaissance Program (URP), a reconnaissance lake sediment and water survey was conducted over about one-half of Labrador. In 1979 all the data became available and were used, in conjunction with the geological information, to select nine follow-up areas with high potential for base metal mineralization. The purpose of the follow-up surveys was three-fold: firstly, to determine the effectiveness in Labrador of reconnaissance scale lake sediment surveys as a method of highlighting regions having anomalous bedrock concentrations of base metals; secondly, to obtain information on the significance of the anomalies in terms of base metal mineralization; and thirdly, at the detailed follow-up level, to apply various geochemical exploration methods and interpretative techniques in order to test their effectiveness as prospecting tools in the Labrador environment. Sample media included lake sediment and water, stream sediment and water, soil and rock.

Geochemical Sampling and Analytical Methods

Reconnaissance and initial follow-up surveys involved the collection of lake sediment and water samples. Center lake sediments were collected with a Hornbrook sampler lowered by a hand-operated winch mounted on the side of a float-equipped helicopter. The material so collected consists of varying proportions of planktogenic and coprogenic ooze and fine grained clastic sediment. The sediment was transferred from the sampler to a numbered kraft paper bag. Various sample and lake parameters such as color, texture, lake depth and lake surroundings, which might have a bearing on sample composition, were noted at each site on computer coding forms. The form is illustrated in Appendix B. A water sample was collected at each site by filling a 250 mL plastic sample bottle held several centimetres under the lake surface. Water color and clarity were noted.

Streams were sampled at 250 m intervals along their length and small tributaries were sampled just above their confluence with the main stream. At most sites active stream silt was hand-scooped into kraft paper sample bags. In some cases only organic-rich sediment and stream bed material were obtained. Stream water was collected in plastic 250 mL sample bottles immediately upstream of all sediment sites. In several instances no sediment samples were obtainable and only water samples were collected, particularly from streams meandering through boggy areas. As with lake samples, several parameters which might influence the chemical composition of the stream samples, such as stream depth, width, flow rate, water color and clarity, were recorded at each site.

Soil samples were collected from two areas, Anomalies 3 and 8. At most sites a podzolic soil profile has developed over locally derived till. Samples of B horizon material, usually encountered at a depth of 10 to 30 cm, were preferentially collected. At some sites only organic-rich material was obtained. Samples were not taken from extremely boggy and peaty locations. Coding forms were used in the field to record 21 variables at each site including location, topography, soil type, sample depth, drainage, and proximity to, and nature of, outcrops.

Rock samples were collected to permit comparison of surficial and bedrock geochemistry, to determine background levels of metals in bedrock and, in some cases, to characterize mineralization. In most cases a 2 to 3 kg representative sample of minimally weathered bedrock was obtained. Frost-heaved material was sampled if it was mineralized or suitable outcrop was not available.

For a description of sample preparation and analytical methods the reader is referred to Appendix A.

Handling of Data from Follow-up Surveys

Field notes pertaining to samples were recorded during sample collection on numerically coded forms. The data were then keypunched and stored on magnetic tape. Examples of these forms are reproduced in Appendix B (Figures B-1 to B-4). Analytical data were also recorded on forms suitable for direct keypunching. The two data sets for a given sample type were then merged into a single data set using an IBM 370 computer.

Several statistical packages are available commercially to manipulate the data sets including SPSS[1], SAS[2], and GAS[3]. The SPSS system was used to determine simple statistical measurements such as means and standard deviations, to perform log transformations as required, and to calculate multi-element statistics such as correlation ma-

[1] Statistical Package for the Social Sciences, McGraw-Hill Inc. N.Y., N.Y.
[2] Statistical Analysis System SAS Institute Inc., Cary, North Carolina.
[3] Geochemical Analysis System, Queen's University, Kingston, Ontario.

trices, single and multiple linear regression equations and residuals. Considerable use was made of a computer-driven Calcomp belt-bed plotter to produce maps of hand-drafted quality rapidly and accurately.

Acknowledgements

This report results from the efforts of many people. In particular, I would like to acknowledge the contribution of the field crews composed largely of Memorial University students who from 1979 through 1981 labored hard, long and usually cheerfully doing the sampling of the follow-up surveys. Wayne Tuttle and his assistants ably provided expediting service from Goose Bay. Hank Wagenbauer and his staff of the Mines and Energy laboratory performed most of the analyses for the follow-up surveys. The late Mike Mackey provided considerable assistance in data processing and his good humor in the computing room is sorely missed. The numerous figures were produced by Dave Leonard and Tony Paltanavage under the direction of Ken Byrne. The manuscript benefitted considerably from critical reading by Dan Boyle and Eldon Hornbrook of the Geological Survey of Canada, and from the keen editor's eye of Jane Murray of the Newfoundland Department of Mines and Energy.

Finally, I would like to acknowledge and thank Peter Davenport, who provided the outline of the project and who also reviewed the rough manuscript.

CHAPTER 2

RECONNAISSANCE LAKE SEDIMENT AND WATER SURVEY

Introduction

The reconnaissance lake sediment and water survey, funded by the Canada and Newfoundland governments, was conducted over a 134,000 km^2 area of Labrador during the summers of 1977 and 1978. Samples were obtained from 8048 sites at a density of approximately one sample per 17 km^2. The survey was designed to furnish the exploration industry with data on bedrock composition and to identify metalliferous areas as large scale prospecting targets. The raw data were published as single element maps at a scale of 1:250,000 (Geological Survey of Canada/Newfoundland Department of Mines, 1978 and 1979).

Regional Geology and Mineralization

The URP survey encompassed portions of four structural provinces of the Canadian Shield: the Superior, Churchill, Nain and Grenville Provinces (Figure 2-1). The regional geology is described below by province.

Superior Province

A 2700 km^2 sliver of the most easterly extension of the Superior Province was surveyed. This area has been mapped only at a reconnaissance scale but is believed to be underlain entirely by Archean rocks of the Ashuanipi Complex consisting of granitic gneiss, amphibolite, and massive felsic intrusions (Greene, 1970). This terrain was metamorphosed to granulite facies during the Kenoran Orogeny (2400-2500 Ma). No significant base metal mineralization has been found in this portion of the Superior Province.

Churchill Province

The largest part of the survey covers a 45,000 km^2 area of the Churchill Province. This province can be subdivided into a western belt of geosynclinal sedimentary and volcanic rocks of the Labrador Trough and an eastern zone of gneiss, migmatite and intrusives.

The Labrador Trough is a 1000 km long belt of Aphebian rocks consisting of sedimentary rocks intercalated with, and intruded by, predominantly mafic volcanic and intrusive rocks. The Trough may be divided length-wise into two distinctive lithological belts: the western portion is dominantly composed of sedimentary rocks whereas the eastern zone consists largely of mafic intrusive and volcanic rocks with subordinate sedimentary rocks. The Trough rocks within the survey area were variably deformed and metamorphosed during the Hudsonian Orogeny, 1600-1800 Ma. The rocks in the extreme south of the survey area were also affected by the subsequent Grenvillian Orogeny, ca. 950 Ma.

In the western portion of the Churchill Province, the Hudsonian Orogeny resulted in very low metamorphic grades, gentle to open folding, and thrusting which in some areas faulted the Aphebian sedimentary rocks against the Archean cratonic rocks to the west. Toward the east, metamorphic grade and intensity of deformation increase markedly so that in many places the eastern boundary of the Labrador Trough is obscured. Much of the gneiss and migmatite in the eastern part of the province may represent reworked Aphebian strata.

Extensive regions in the central and eastern part of the Churchill survey area are underlain by a bimodal suite of large Paleohelikian granitoid and gabbroid intrusions known as the Nain igneous complex. The intrusions appear to have been emplaced anorogenically (Emslie, 1970), and the suite includes anorthosite, gabbro, granodiorite, adamellite, granite and syenite.

Four small outliers of shallowly dipping, clastic sedimentary rocks of probable Helikian age overlie portions of the Aphebian rocks in the Labrador Trough (Ware, 1979). An outlier of undeformed Helikian or Hadrynian arkose is preserved in the eastern region of the Grenville survey area. In addition, a moderate expanse of Neohelikian sedimentary and volcanic rock underlies the south-central portion of the survey area.

Base metal mineralization in the Churchill survey area may be grouped into two general associations. One type is found in Aphebian sedimentary rocks of the Labrador Trough and in mafic dikes and sills intruding them. Most of these occurrences are toward the eastern margin of the Trough. They are discussed in detail in the following chapter. A second type consists of Cu-Ni mineralization associated with gabbroic to anorthositic intrusions of the Nain igneous complex. Those found to date have been of low grade and composed of chalcopyrite and pyrrhotite.

Nain Province

The Nain-Churchill structural boundary has been largely obliterated by the large Elsonian intrusions of the Nain igneous complex described above. About 12,000 km^2 of the survey area may be considered as falling within the bounds of the Nain Province. Of this, about half is underlain by gneiss and the other half by intrusive rocks of the Nain igneous complex. K-Ar dates from the gneiss typically range from 2390 to 2665 Ma suggesting that these are Archean rocks which were metamorphosed during the Kenoran Orogeny (Emslie, 1970).

A distinctive group of magmatic rocks described by Hill (1981) is associated with the Nain igneous complex but is

somewhat younger and is known as the Flowers River Igneous Suite. These rocks consist of a subaerial felsic volcanic assemblage and a younger but related peralkaline granite. Several occurrences of mineralization have been recognized in the suite, particularly pyrite, sphalerite, galena and fluorite. Some are enriched in rare earth elements. One sample of a peralkaline granite dike analyzed 2% zirconium and was also enriched in niobium and yttrium (Hill, 1982).

Grenville Province

The area sampled in 1977 is underlain predominantly by granitic intrusions and gneiss, anorthosite and gabbroic rocks. The rocks were metamorphosed during the Grenvillian Orogeny about 950 Ma. Flat lying sedimentary supracrustal rocks of Hadrynian age are found in two locations. Only minor base metal mineralization is known from this area of the Grenville Province. The boundary between the Grenville and Nain Structural Provinces is gradational (Gower et al., 1980) and is shown in Figure 2-1 by a line representing a position midway between the northern limit of brittle deformation and the northern limit of ductile deformation. On the basis of recent 1:100,000 mapping in the predominantly gneissic area to the north and east of Lake Melville, Gower (1984) proposes to subdivide this part of the Grenville Province into a northern Groswater Bay Terrane and a southern Lake Melville Terrane. These two arcuate terrains center about Lake Melville and are bounded by the Benedict Mountains granitoids to the north and the Mealy Mountains anorthosite suite to the south. The two terraines are separated by major thrust faulting along the east and by normal faulting along the north. The boundary runs northeasterly a few kilometres north of Lake Melville and then swings southeasterly from the head of Groswater Bay through Sandwich Bay. Metamorphic grade increases southeasterly across Groswater Bay Terrane from greenschist to middle amphibolite facies. The northern margin of the Lake Melville Terrane is typified by granulite facies rocks which grade southward into middle amphibolite facies assemblages. Although only a small portion of the area (10% ?) is underlain by paragneiss, most of the molybdenum and copper occurrences are associated with such rock (Gower and Erdmer, 1984). No follow-up surveys of base metal anomalies were done in the Grenville Province.

Geochemistry

Introduction

This section outlines the method of summarizing the reconnaissance data. Intervariable correlations and relationships are considered, particularly in terms of how they obscure dispersion patterns in lake sediments. An application of linear regression analysis is described by which some of the effects which complicate interpretation are removed. Finally, maps of dispersion patterns of selected base metals are presented and discussed in terms of bedrock geology and mineralization.

Summary of Data

In order to simplify presentation and to enhance regional scale dispersion patterns by reducing local scale geochemical "noise", the data from the 8048 reconnaissance sites were aggregated into 1386 cells. The aggregation process employed a method developed by P.H. Davenport (personal communication) in which the survey area was divided into square cells, 10 km on a side. Geometric means were calculated for the analytical data from all sample sites falling within a cell, except for pH and LOI for which arithmetic means were calculated. In the few cases where only one sample site fell within a cell, that sample was transferred to the closest adjacent cell and no values were calculated for the empty cell. An "average" cell is thus a composite of 5.8 samples. This aggregated data set is the basis for deriving all statistics, correlations and dispersion patterns discussed in the following sections. It permits the examination of inter-element correlations of the summarized data, and allows the application of multivariate statistical techniques.

Statistics and Inter-element Relationships

Data were processed with an IBM 370 computer using a statistical package, SPSS, described by Nie et al. (1975). The mean abundances and standard deviations of elements and variables from the aggregated data set are tabulated in Table 2-1.

Table 2-1: Means and standard deviations of aggregated lake data.

Lake Sediment		
	Mean*	Standard Deviation*
Cu	17.7	0.229
Pb	1.82	0.249
Zn	67.6	0.212
Co	6.37	0.262
Ni	9.51	0.271
Ag	0.113	0.089
Mn	175.	0.311
Fe (%)	1.69	0.249
Mo	2.30	0.429
U	1.91	0.429
F	135.	0.299
LOI (%)	26.9	8.44
Depth (m)	8.08	0.326

Lake Water		
U (µg/L)	19.5	0.512
F (µg/L)	30.3	0.244
pH	6.21	0.40

* 1. Arithmetic means and standard deviations are given for LOI and pH, geometric means and $\log_{10}$ S.D. for other data.
2. Means are expressed in g/t except for pH and as noted.

Table 2-2: Correlation coefficients for aggregated lake sediment and water data. Coefficients between ± 0.06 are not significant at the 95% confidence level. n = 1386

		Cu	Pb	Zn	Co	Ni	Mn	Fe	Mo	U	F	LOI	Depth	U	F	pH
Sediment	Cu	1.00														
	Pb	.37														
	Zn	.53	.47													
	Co	.59	.29	.65												
	Ni	.67	.34	.50	.65											
	Mn	.41	.41	.64	.76	.41										
	Fe	.37	.33	.64	.75	.36	.81									
	Mo	.35	.44	.50	.38	.12	.37	.41								
	U	.42	.48	.28	.20	.06	.25	.27	.63							
	F	.41	.53	.53	.50	.32	.49	.51	.46	.48						
	LOI	−.00	−.24	−.11	−.26	−.05	−.25	−.24	−.13	−.22	−.50					
	Depth	.54	.35	.44	.54	.31	.44	.40	.48	.33	.44	−.18				
Water	$U(H_2O)$	.19	.41	.21	.14	.09	.14	.11	.49	.68	.34	−.15	.21			
	$F(H_2O)$	−.24	.21	.04	−.20	−.43	.31	.01	.37	.37	.15	−.01	−.15	.31		
	pH	.24	.27	.52	.39	.52	.32	.24	.37	.08	.29	−.10	.37	.27	−.14	1.00
		Cu	Pb	Zn	Co	Ni	Mn	Fe	Mo	U	F	LOI	Depth	U	F	pH
		← Sediment →												← Water →		

To assess linear relationships between pairs of variables, Pearson correlation coefficients (Nie et al., 1975, page 280) were calculated and are presented in Table 2-2. The values, which can range from −1.00 to 1.00, are a measure of the strength and direction of correlation between variables pairs. Some of the more interesting correlations are as follows:

1) Generally strong positive correlations among the base metals Cu, Zn, Co and Ni. These likely result from their common association in rocks and their generally similar mobilities in surficial environments.

2) Moderate to strong positive correlations of Fe and Mn with Cu, Zn, Co, Ni, Mo, F and depth. Since Fe and Mn have similar geochemical properties, consideration of the correlation effects of either will usually be sufficient. The correlation of an element with Fe likely reflects, in part, its tendency to coprecipitate with hydrous Fe-oxides and to be adsorbed by freshly precipitated oxides. The correlation of Fe with depth suggests that in Labrador the Eh-pH conditions in deeper lakes are more conducive than those in shallower lakes to the precipitation of Fe. Conditions favorable to increased precipitation would be shifts to higher pH and higher Eh (more oxidizing). Evidence for the first condition is found in the positive correlation (0.37) of depth and pH. Indirect evidence for the second is the negative correlation of depth and LOI since lower organic contents would permit more oxidizing conditions.

3) Moderate to strong positive correlations of depth with Cu, Zn, Co, Mn, Fe, Mo and F. Some of these trace element correlations may be accounted for by the Fe-depth and Fe-trace element correlations noted above. In the cases of Cu and Mo, however, correlation with depth is stronger than with Fe. As in the case of Fe noted in (2), the correlations with depth are likely reflecting Eh-pH conditions. Additionally, if lake depth correlates with the degree of fineness of sediment deposited, one might expect the high cation exchange capacity of the clay-size material to result in an increased concentration of many trace elements in the lake sediment.

4) Generally negative correlation of elements with LOI; the correlation is particularly strong (−0.50) with F. The negative correlations likely reflect, in part, a dilution effect caused by the mixing of organic matter of low trace element content with materials of higher trace element content which have components of detrital, precipitated and adsorbed origins.

5) Moderately strong negative correlations of F in water with Cu and Ni in sediment and moderately strong positive correlations of F in water with Mo and U in sediment. Both sets of correlations can be ascribed to primary bedrock associations. High F, U and Mo contents are typical of many highly fractionated silicic igneous rocks whereas high Cu and Ni but low F are characteristic of their mafic counterparts.

6) Weak positive correlation (0.15) of F in water and sediment. Fluorine in sediment correlates very strongly with several environmental factors, particularly Fe, LOI and depth; dispersion patterns for F in sediment and F in water therefore may differ markedly.

From the above discussion it can be argued that the variables depth, Fe, Mn and LOI, are indirect indicators of the physical and chemical environment within the lakes. Variation of these parameters can cause considerable change in the concentration of many elements in the sediment regardless of the composition of the bedrock.

The Effects of Lake Depth and Fe Content on Sediment Composition

The effects of variations in depth and Fe are shown graphically in Figures 2-2 and 2-3. The values for Figure 2-2 were obtained by sorting the 1386 cells into subgroups based on equal geometric increments of depth. The geometric mean of each element was then calculated for each subgroup. A similar procedure using increments of Fe was used to obtain the values for Figure 2-3. An examination of the trace element trends with depth (Figure 2-2) reveals the following:

1) Concentration trends for most elements are nearly linear and positive over the entire range of depth. Exceptions include Fe and Mn which are slightly elevated in very shallow (<1 m) lakes. Also exceptional is Ni, the concentration of which declines at depths greater than 6 m.
2) The increases in element concentrations with depth range from a two-fold increase for Ni to a four-fold increase for Mn.

The relationship of Fe to trace element content is depicted in Figure 2-3 and includes the following:

1) Concentrations of the metals Mn, Ni, Zn and Co form very linear and positive relationships with Fe content.
2) The trend of Cu follows very closely that of depth. Both have nearly constant values for Fe <0.9% and positive linear trends at higher Fe concentrations.
3) The upward trends of F, Ni, and Mo are interrupted at 0.7% Fe, which also coincides with a downturn in the depth trend. This observation suggests that the distributions of these elements, like that of Cu, are more strongly influenced by depth than are the distributions of Zn and Co.
4) Maximum increases in concentrations of ore metals with increasing Fe, range from a 2.2-fold increase in Cu to an 8.3-fold increase in Co.

Linear Regression Analysis

Of the elements selected for illustration of typical dispersion patterns, Cu, Mo, Zn and Ni correlate most strongly with one or both of the environmental factors depth and Fe. Consequently, an attempt has been made to remove these environmental effects by using the statistical technique of two-step linear regression. The general format of the equation used to calculate residual values is given in Table 2-3. In essence the residual value is derived by subtracting the predicted element concentration from the analyzed concentration. This residual is then standardized by dividing it by the standard error of estimate of the regression equation.

Table 2-3: Format of equations to calculate residual trace element concentrations.

$$RE = (E - (K + aX_1 + bX_2)) \div s$$

where:
- RE = residual element concentration in standard deviations from the regression line
- E = log of element concentration of Zn, Cu, Mo or Ni
- K = constant
- a and b = regression coefficients
- X_1, X_2 = log values of environmental factor (depth or Fe)
- s = standard error of estimate

The actual equations used are given in Table 2-4. For Cu and Mo, depth accounts for more of the variation due to nongeological factors whereas for Zn and Ni, the Fe content accounts for more of the variation. The proportion of the variance (r^2) accounted for by these environmental factors varies considerably. The regression equation for Zn accounts for 45% of the variance whereas the equation for Ni accounts for only 16%.

Table 2-4: Equations for calculating residual trace element concentrations. r^2 is the proportion of the proportion of the variance explained by the regression.

Residual Copper =	[log Cu − (0.88091 + 0.32765 (log Depth) + 0.16628 (log Fe))] ÷ 0.18924
	r^2 = 0.32
Residual Zinc =	[log Zn − (1.58079 + 0.47154 (log Fe) + 0.14095 (log Depth))] ÷ 0.15731
	r^2 = 0.45
Residual Nickel =	[log Ni − (0.74091 + 0.30807 (log Fe) + 0.16628 (log Depth))] ÷ 0.24827
	r^2 = 0.16
Residual Molybdenum =	[log Mo − (−0.076858 + 0.36538 (log Depth) + 0.31498 (log Fe))] ÷ 0.26279
	r^2 = 0.29

Lake Sediment Geochemistry in Relation to Bedrock Composition and Mineralization

Maps of element distributions are presented as Figures 2-4 to 2-13. These include the elements Cu, Ni, Zn, Mo, Pb

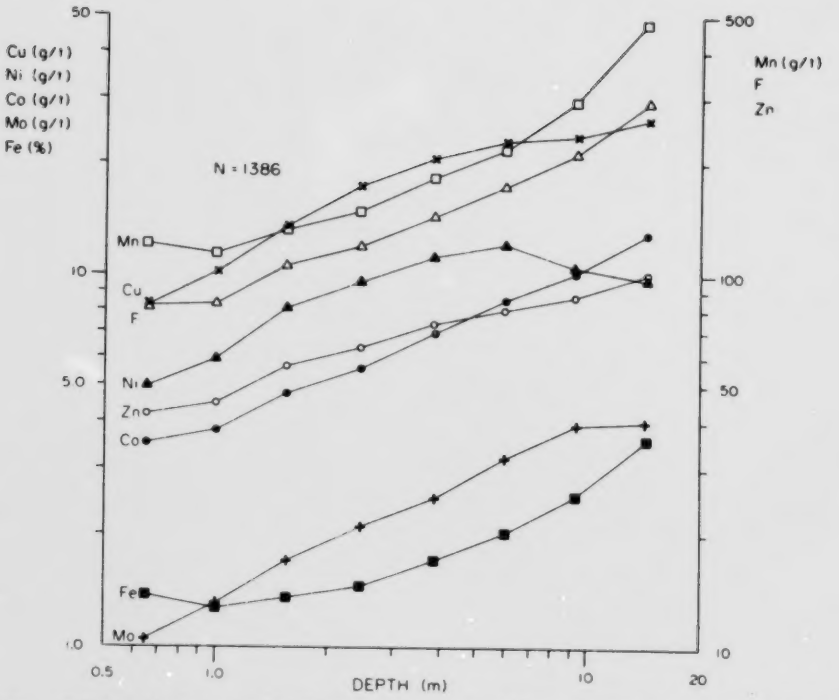


Figure 2-2: Relationship between depth and composition of lake sediment in reconnaissance data.

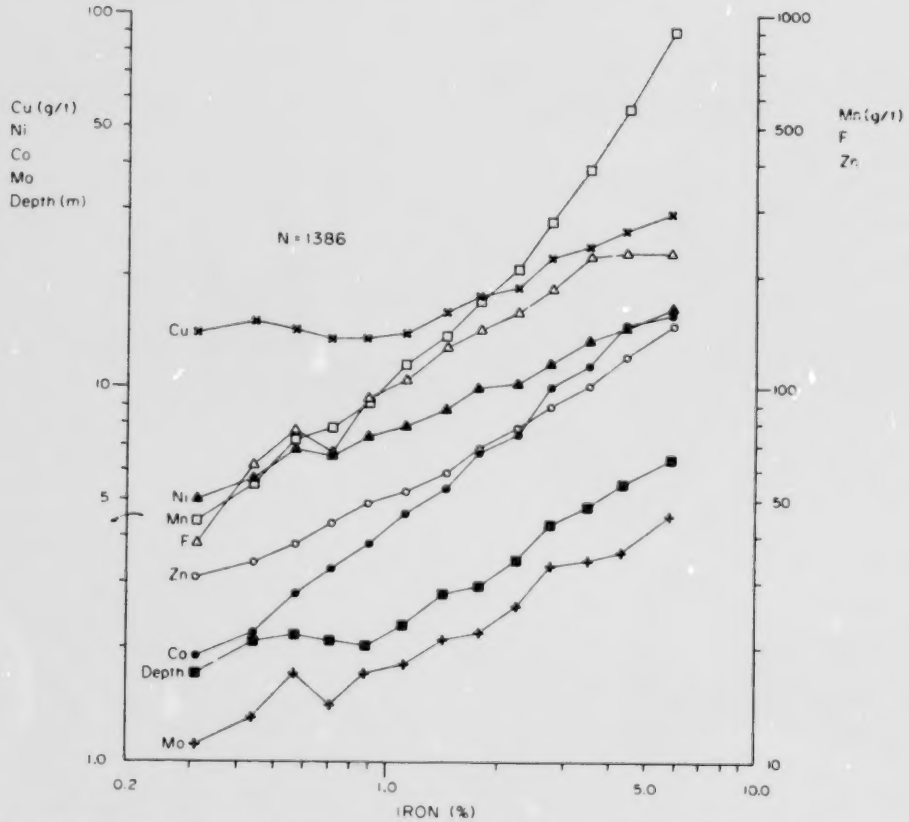


Figure 2-3: Relationship between Fe and composition of lake sediment in reconnaissance data.

and Ag and residuals of Cu, Ni, Zn and Mo. For reasons of clarity, only the upper 20% of the data are shown and are contoured at the 98th, 95th, 90th and 80th percentiles. The terms "first order", "second order" and "third order" anomalies as applied here refer to values which fall within the highest three categories.

Copper and Residual Cu

The distributions of first order anomalies of Cu and residual Cu are summarized in Table 2-5 and the dispersion patterns are depicted in Figures 2-4 and 2-5. The locations described in the table are outlined in the figures. Copper mineralization is known to occur in locations A, B, E, F, G and H with the most significant occurrences being those in the Labrador Trough and those in the Central Mineral Belt. Areas in which anomalies occur but which have no known Cu mineralization have, in general, received little exploration attention. Of the six mineralized areas, two are anomalous (first order) only in Cu, two only in residual Cu and two, the northern Labrador Trough, in both. This suggests that both methods of identifying areas with high background levels of Cu should be used.

Table 2-5: Distribution of first order anomalies of Cu and residual Cu.

	Location	Probable Host Rocks	Cu	Residual Cu
A	N. Labrador Trough	sedimentary rocks and gabbro	X	X
B	S. Labrador Trough	metasedimentary rocks		X
C	Churchill Province E. of Labrador Trough	amphibolite		X
D	N. Churchill Province	paragneiss	X	X
E	Superior Province	mafic igneous rocks		X
F	Central Mineral Belt	volcanic and sedimentary rocks		X
G	Grenville Province, W. of Lake Melville	paragneiss and granitoid rocks	X	X
H	Grenville Province NE of Lake Melville	gabbro and paragneiss		X

It should be noted that several occurrences of low grade (≃0.1%) Cu-Ni mineralization are known in the large Harp Lake Anorthosite (southeast Churchill Province) and are not reflected as first order Cu anomalies although a first order residual Ni anomaly is present.

Nickel and Residual Ni

The distribution of first order anomalies of Ni and residual Ni is summarized in Table 2-6 and depicted in Figures 2-6 and 2-7. Of all elements plotted, the anomalies of Ni and residual Ni are the most restricted in area occurring in only five locations. Ni mineralization is uncommon in the survey area with the only occurrences of significance being in the northeast Labrador Trough and the Harp Lake Anorthosite of southeast Churchill Province. The first area is reflected in the sediment data by both Ni and residual Ni; the second area by only residual Ni.

Apart from the northern Labrador Trough, the strongest and largest anomalies are found in the Superior Province. Both types of Ni data are anomalous and are roughly coincident with high Cu values. These patterns suggest that much of this part of the Superior Province is underlain by mafic igneous or meta-igneous rocks. Geological mapping in this region is of a reconnaissance nature.

Table 2-6: Distribution of first order anomalies of Ni and residual Ni.

	Location	Probable Host Rocks	Ni	Residual Ni
A	N. Labrador Trough	gabbro and black shales	X	X
B	S. Labrador Trough	metasedimentary rocks		X
C	Superior Province	mafic igneous rocks	X	X
D	N.E. Churchill Province	paragneisses		X
E	Harp Lake Anorthosite	leucogabbro		X

Location D in northeastern Churchill Province is coincident with a Cu anomaly. The area is underlain by granulite facies pyroxene-garnet gneiss some of which is likely paragneiss. Follow-up lake sediment sampling in this area (Anomaly 14) yielded maximum sediment analyses of 203 g/t Cu and 311 g/t Ni. Although gossans were noted from the air little groundwork has been done. This anomaly is discussed in more detail in Chapter 5.

Zinc and Residual Zn

The distribution of first order anomalies of Zn and residual Zn are summarized in Table 2-7 and depicted in Figures 2-8 and 2-9. Known Zn mineralization is restricted to the northern Labrador Trough, the Central Mineral Belt and the Flowers River Igneous Suite. All three areas are highlighted by first order anomalies of Zn and residual Zn. Three other areas which have economic promise are locations B, C and D in Table 2-7. Detailed lake sediment sampling of anomalous areas in the southern Labrador Trough (location B, Anomalies 6 and 7) yielded Zn analyses up to 1400 g/t (see Chapter 4).

Two areas within the URP survey are known to be underlain by peralkaline granitic rock, the Flowers River Igneous Suite (location F), and a small granite straddling the Quebec-Labrador border in the Strange Lake area 140 km west of Nain. Such rocks are abnormally enriched in large-ion lithophile elements as well as Zn. The Flowers River suite (location F) is clearly anomalous both in Zn and residual Zn. The smaller peralkaline body is only slightly reflected in the raw Zn data by a fourth order anomaly (Figure 2-8) but yields a second order residual Zn anomaly (Figure 2-9).

A more puzzling area is location C. Here, a strong Zn anomaly and stronger residual Zn anomaly are located in

the northeastern portion of the Michikamau Intrusion, a layered anorthosite. Lakes over the southeastern part of the intrusion were sampled during the 1982 field season and analytical results are not yet available. The highest Zn values are associated with the leucotroctolite phase (a plagioclase-olivine rock). The anomaly, somewhat reduced in intensity, extends southeastward across the high grade metamorphic terrain underlain by quartzofeldspathic gneiss and granulite. The latter area is down-ice from the anorthosite and may be reflecting glacial transport of material from the anorthosite.

Table 2-7: Distribution of first order anomalies of Zn and residual Zn.

	Location	Probable Host Rocks	Zn	Residual Zn
A	N. Labrador Trough	black shale and gabbro	X	X
B	S. Labrador Trough	metasedimentary rocks	X	X
C	S. Churchill Province (E. of Labrador Trough)	leucotroctolite and gneiss	X	X
D	Northern Churchill Province	paragneiss		X
E	Harp Lake Anorthosite	leucotroctolite		X
F	Central Nain Province	peralkaline granitoid and volcanic rocks	X	X
G	Central Mineral Belt	volcanic and sedimentary rocks	X	X
H	S.E. Nain Province	granitoid rocks		X
I	Grenville Province	quartzofeldspathic gneiss		X

First order anomalies of residual Zn also occur in the Harp Lake Anorthosite 75 km to the northeast. Exploration in this area during the 1970's resulted in the discovery of several occurrences of Cu-Ni mineralization but none of Zn.

Location D in northern Churchill Province is a multi-element anomaly of Zn, Cu and Ni. The area is underlain by gneiss, probably paragneiss in part.

Molybdenum and Residual Mo

The distribution of first order anomalies of Mo and residual Mo is given in Table 2-8 and the dispersion patterns are illustrated in Figures 2-10 and 2-11.

In most instances the anomalous areas defined by the two criteria are similar but there are some notable differences. The most notable, perhaps, is location B (Table 2-8) situated 75 km east of the Labrador Trough on the northwest margin of the Michikamau Anorthosite. The area is underlain by granite. The residual Mo data (Figure 2-11) indicate a first order anomaly whereas the Mo data (Figure 2-10) reveal only a third order anomaly. Moreover, concentrations of F in lake water from this area are among the highest found in the Labrador reconnaissance survey, with several samples in excess of 400 µg/L. By contrast, the mean F in water of the entire survey is 30µg/L. Together with the residual Mo data, this suggests that the bedrock is a highly fractionated granite and a possible host for a variety of mineral deposits associated with such bodies.

Table 2-8: Distribution of first order anomalies of Mo and residual Mo.

	Location	Probable Host Rocks	Mo	Residual Mo
A	Superior Province	gneisses or felsic igneous rocks	X	X
B	Churchill Province, E. of Labrador Trough	granitoid rocks		X
C	N.W. Churchill granite	X	X	
D	Churchill Province	gneiss	X	X
E	Central Nain Province	normal and peralkaline granitoid rocks	X	X
F	Central Mineral Belt	granite, volcanic and gneissic rocks	X	X
G	Grenville Province, W. of Lake Melville	granitoid rocks		X

Two of the largest anomalous regions, locations E and F, are areas with numerous occurrences of molybdenite mineralization. Location E in central Nain Province is centered over peralkaline granite of the Flowers River Igneous Suite but also includes portions of many small granitic intrusions of the Nain igneous complex. Molybdenite mineralization is recorded from both rock suites (Hill, 1981).

More extensive and significant Mo mineralization is known from location F in the Central Mineral Belt. Here the first order Mo and residual Mo anomalies (Figures 2-10 and 2-11) extend over Archean gneiss, Aphebian volcanic rock and Helikian granite of the Benedict Mountains suite. Molybdenite mineralization occurs in all of these groups (Douglas, 1976, and Gower et al., 1982).

Several isolated first order Mo and residual Mo anomalies occur in location C, over the Mistastin Batholith of northwest Churchill Province. They suggest that it is a multiphase intrusive complex containing highly fractionated phases. Mapping by Emslie et al. (1980) resulted in the broad subdivision of the batholith into two major granitic phases: (1) a pyroxene-hornblende quartz monzonite underlying the central and northeastern portion; and (2) a biotite-hornblende granite underlying the northwestern and southern portions and a small area centrally located along the eastern edge of the body. Disseminated fluorite occurs widely in the northern and southern areas of the biotite-hornblende phase. The distribution of first order Mo and residual Mo anomalies coincides closely with the areas underlain by the more felsic phase, particularly the fluorite-bearing regions.

Lead

The distribution of first order Pb anomalies is given in Table 2-9 and the dispersion patterns of Pb are illustrated in Figure 2-12. The absolute values of Pb in the Labrador lake sediments are low, having a mean concentration of only 1.8 g/t; by comparison the mean concentration in lake sediments from the island portion of Newfoundland is 6.7 g/t (Davenport, personal communication). Doubtlessly this contrast reflects the lower levels of Pb in the Precambrian rocks of Labrador relative to the predominantly Paleozoic rocks of Newfoundland. Nonetheless, the Pb patterns in the Labrador data are significant and can be included with areas of known base metal mineralization. The configurations of the Pb patterns are, in several instances, similar to those of Cu, Zn and Mo. Similarities with both Cu and Zn are particularly prominent in the north and south Labrador Trough and the Central Mineral Belt. Examples of base metal mineralization are known from all three areas. A significant difference between the patterns occurs toward the northeastern margin of the Labrador Trough where Pb values decline but those of Cu, Ni and to a lesser extent Zn, are very high. This area has many occurrences of Cu-Ni(-Zn) mineralization but Pb mineralization is not prominent.

Table 2-9: Distribution of first order anomalies of Pb.

	Location	Probable Host Rocks
A	N. Labrador Trough	black shales and gabbro
B	S. Labrador Trough	slates, schists and gabbro
C	N.W. Churchill Province	down-ice from peralkaline granitoid
D	Central Nain Province	peralkaline granitoid and volcanic rocks
E	Central Mineral Belt	volcanic and sedimentary rocks
F	E. Grenville Province	granite gneiss; possibly contamination from town of Rigolet

In the Central Mineral Belt, two first order anomalies include most of the known occurrences of Cu-Pb-Zn, Mo-Cu-Pb and U-Mo mineralization. Indeed, throughout the survey area, virtually all regions known to host significant occurrences of U mineralization are characterized by at least a third order Pb anomaly.

The strongest and most extensive Pb anomaly is centered over the peralkaline granitoids of the Flowers River Igneous Suite. This is partly coincident with a large first order Mo (and residual Mo) anomaly and a more restricted Zn anomaly. The Pb-Zn anomaly is consistent with the enrichment of Pb and Zn and large-ion lithophile elements found in rocks of this suite (Hill, 1981). Several occurrences of Pb mineralization, usually in association with more prominent Zn mineralization, have been recorded.

The easterly trending dispersion pattern of Pb in the northwestern part of the Churchill Province (location C) probably represents a down-ice and down-drainage dispersion of high Pb values associated with another peralkaline granitic intrusion straddling the Quebec-Labrador border. This body is highly enriched in F, U, Th, Pb, Zn, Zr, Be, Nb, Y and rare earth elements, and hosts the Strange Lake mineral deposit which was found as a result of following up a multi-element anomaly in the regional lake sediment/water survey data.

Silver

The distribution of first order Ag anomalies is listed in Table 2-10 and the dispersion patterns are illustrated in Figure 2-13. Examination of Figure 2-13 indicates that the dispersion patterns are considerably more diffuse than those of other elements. Many of these patterns can be attributed to analytical "noise" which results from the fact that most of the sediment samples analyzed are below the detection limit of 0.2 g/t. Some 59% of the cells in the aggregated data set contain no samples with detectable Ag. Since analytical precision is poor at such low concentration levels, the risk of creating spurious anomalies is increased.

Table 2-10: Distribution of first order anomalies of Ag.

	Location	Probable Host Rocks
A	N. Labrador Trough	black shale, gabbro, volcanic rocks
B	Superior Province	mafic igneous or gneissic rocks
C	S.E. Churchill Province	Helikian supracrustal sedimentary rocks
D	S. Nain Province	granitoid rocks
E	Central Mineral Belt	sedimentary and volcanic rocks
F	Grenville Province (W. of Lake Melville)	mafic intrusives
G	N.E. Grenville Province	gabbro

Nonetheless, broad patterns of elevated Ag concentration do exist. In general Ag distribution does not coincide with that of other elements across the survey region although anomalies may correspond in specific locations. Areas of high Ag values in the northern Labrador Trough, for example, correspond roughly to those of base metals. Portions of the Superior Province also have first order Ag anomalies which correlate in part with first order Ni anomalies. Other notable Ag anomalies occur in the Central Mineral Belt, where they correlate in part with anomalies of Pb, Cu and Zn discussed previously.

Two first order Ag anomalies are found in the Grenville Province. The eastern one is caused by a single sample (0.6 g/t) from a lake adjacent to a large gabbro dike. The western anomaly is supported by several high Ag samples; the source may be a small mafic body intruding the gneissic terrain.

Captions for the Following Foldout Figures

Figure 2-1: *Geology and follow-up anomalies within reconnaissance survey area.*

Figure 2-4: *Cu in lake sediment.*

Figure 2-5: *Residual Cu in lake sediment.*

Figure 2-6: *Ni in lake sediment.*

Figure 2-7: *Residual Ni in lake sediment.*

Figure 2-8: *Zn in lake sediment.*

Figure 2-9: *Residual Zn in lake sediment.*

Figure 2-10: *Mo in lake sediment.*

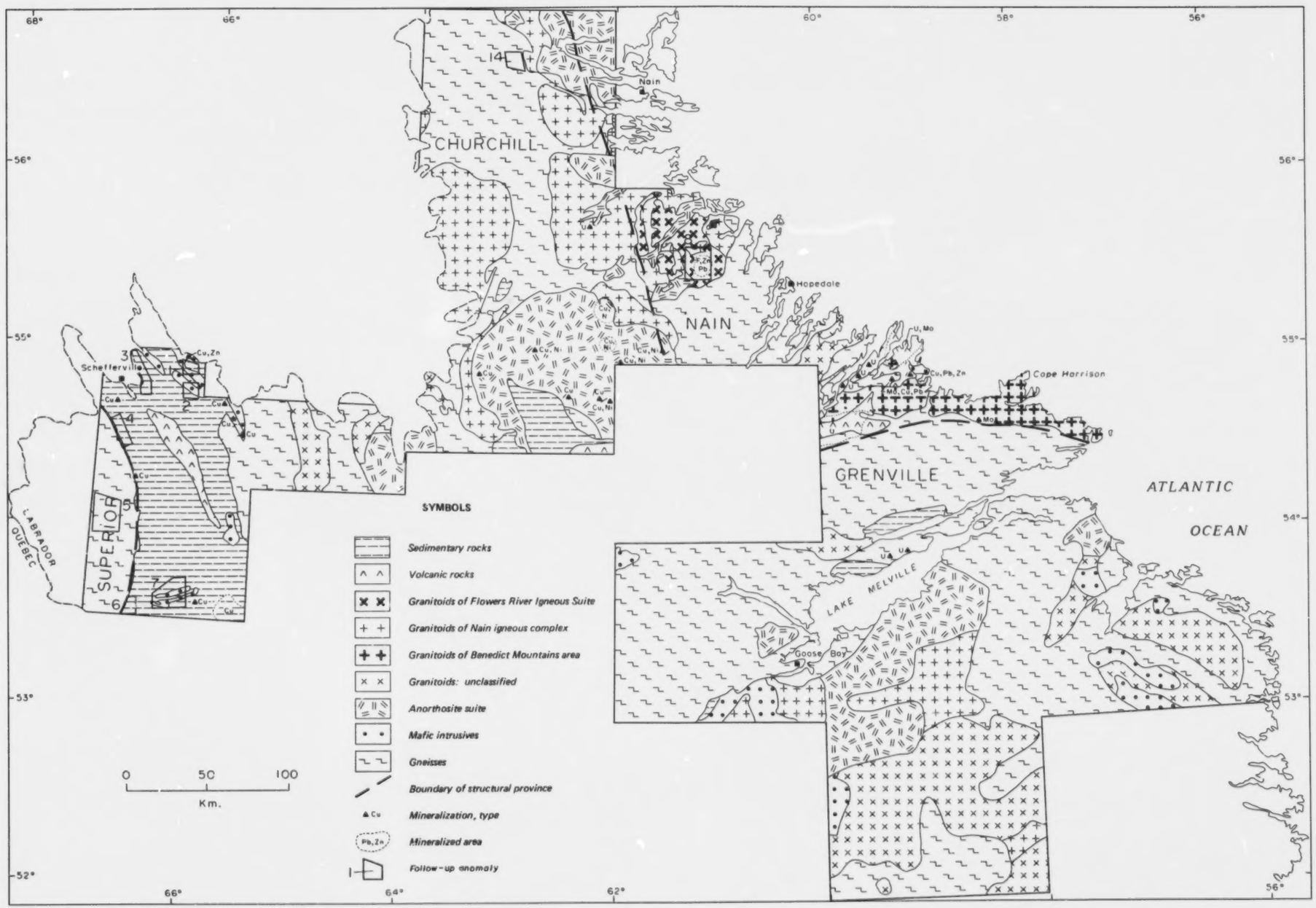
Figure 2-11: *Residual Mo in lake sediment.*

Figure 2-12: *Pb in lake sediment.*

Figure 2-13: *Ag in lake sediment.*

NOTE

The locations of base metal occurrences in the Grenville Province and of the Strange Lake Zr, Nb, Y, Be and rare earth elements deposit in the Churchill Province were omitted from Figures 2-1 and 2-4 through 2-13. These locations are, however, included on the cover illustration which should be used for reference where appropriate.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LAKE MELVILLE
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Goose Bay
Schefferville
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SYMBOLS
Sedimentary rocks
Volcanic rocks
Granitoids of Flowers River Igneous Suite
Granitoids of Nain igneous complex
Granitoids of Benedict Mountains area
Granitoids: unclassified
Anorthosite suite
Mafic intrusives
Gneisses
Boundary of structural province
Mineralization, type
Mineralized area
Follow-up anomaly
0
50
100
Km.

COPPER in sediment

Geochemical contour intervals:

98th percentile (53g/t)
95th percentile (42g/t)
90th percentile (35g/t)
80th percentile (27g/t)

SYMBOLS

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- *Volcanic rocks*
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- *Granitoids of Nain igneous complex*
- *Granitoids of Benedict Mountains area*
- *Granitoids: unclassified*
- *Anorthosite suite*
- *Mafic intrusives*
- *Gneisses*
- *Boundary of structural province*
- ▲Cu *Mineralization, type*
- Pb,Zn *Mineralized area*
- 1 *Follow-up anomaly*
- A *Location described in text*

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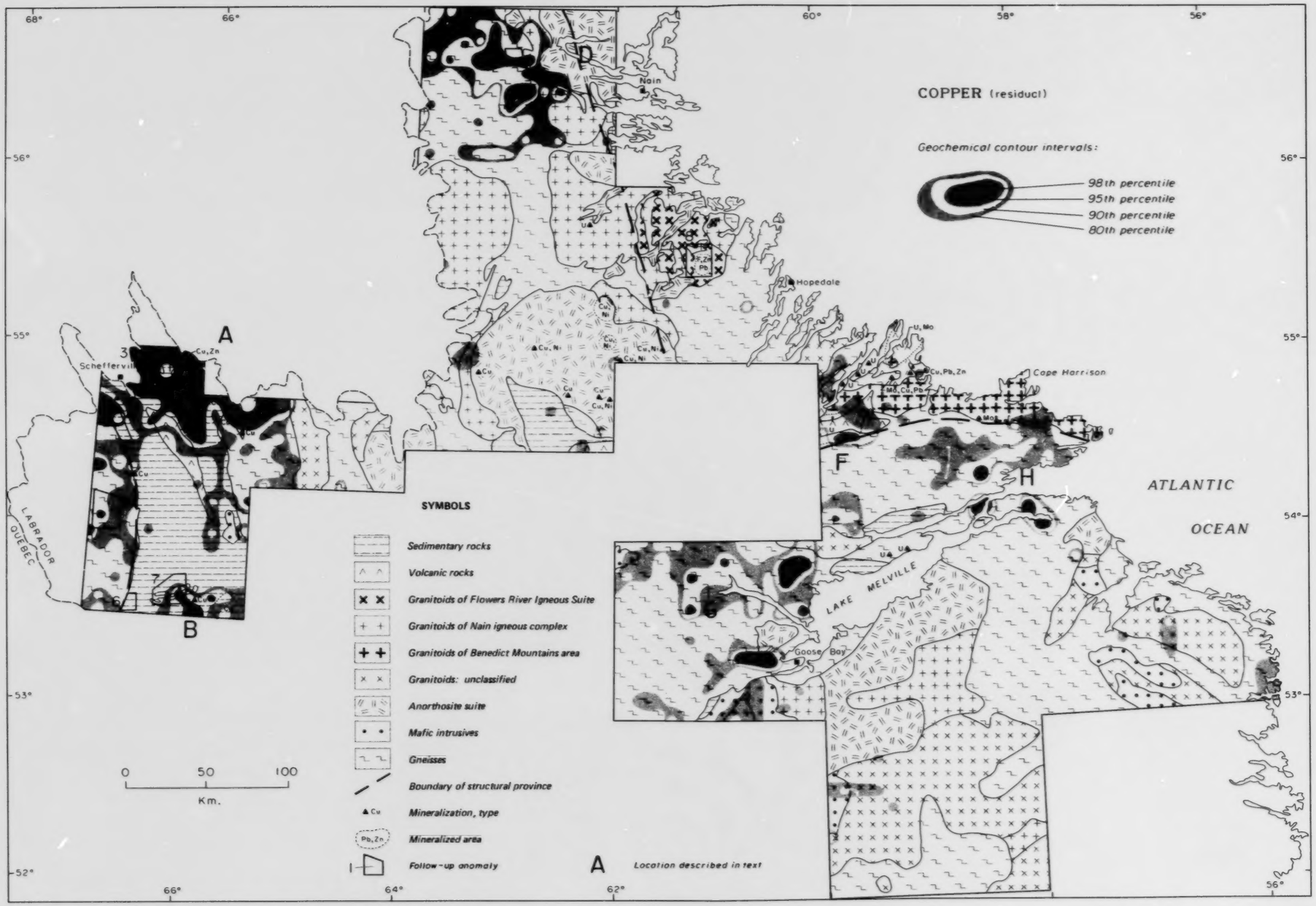
Nain
Hopedale
Cape Harrison
Schefferville
LABRADOR QUÉBEC
LAKE MELVILLE
Goose Bay
ATLANTIC OCEAN

A B C D E F G

Cu,Zn Cu,Ni Cu,Pb,Zn U,Mo Mo,Cu Mo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Follow-up anomaly
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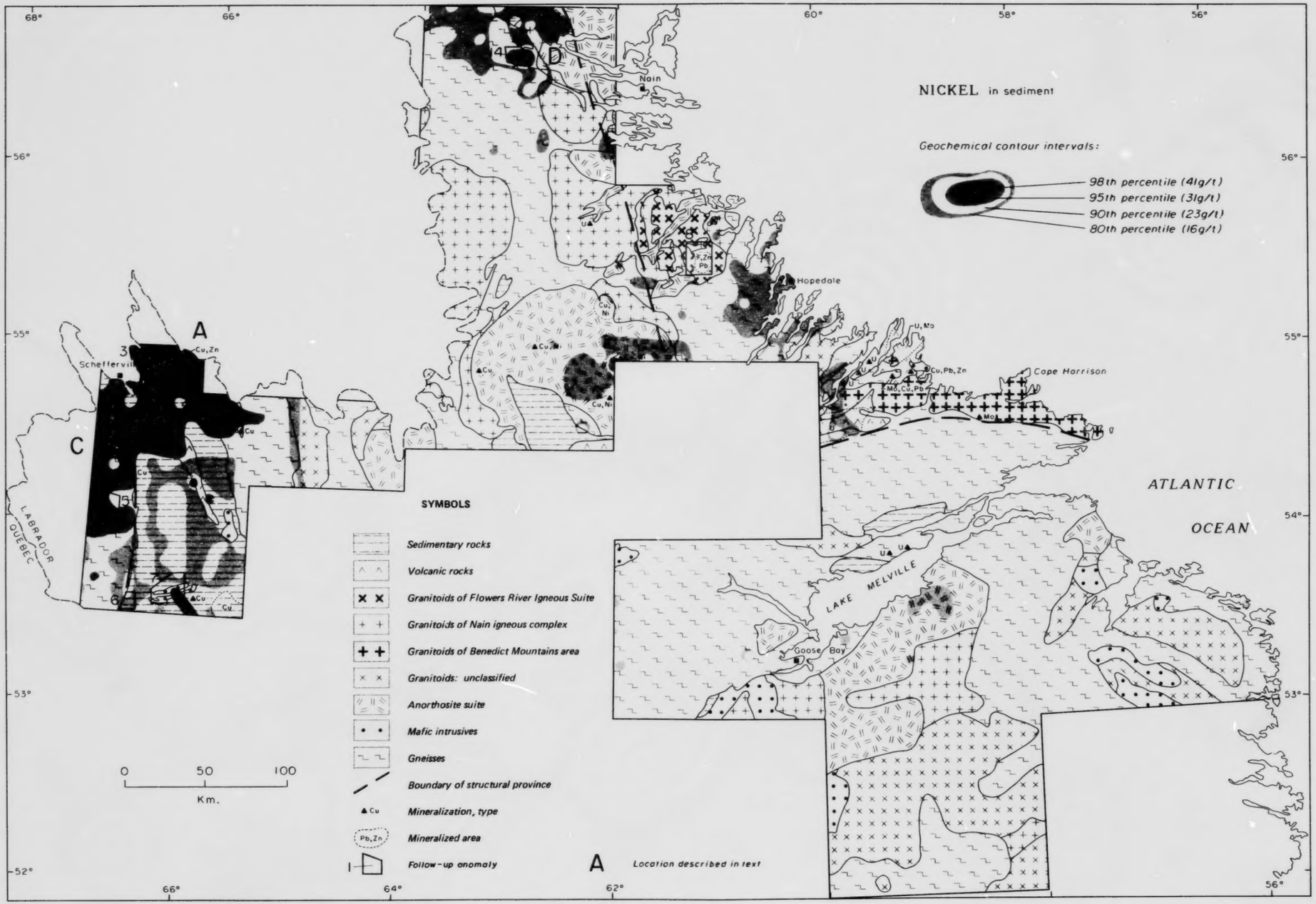
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Cu Mineralization, type
Pb,Zn Mineralized area
Follow-up anomaly
A Location described in text
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Scheffervil
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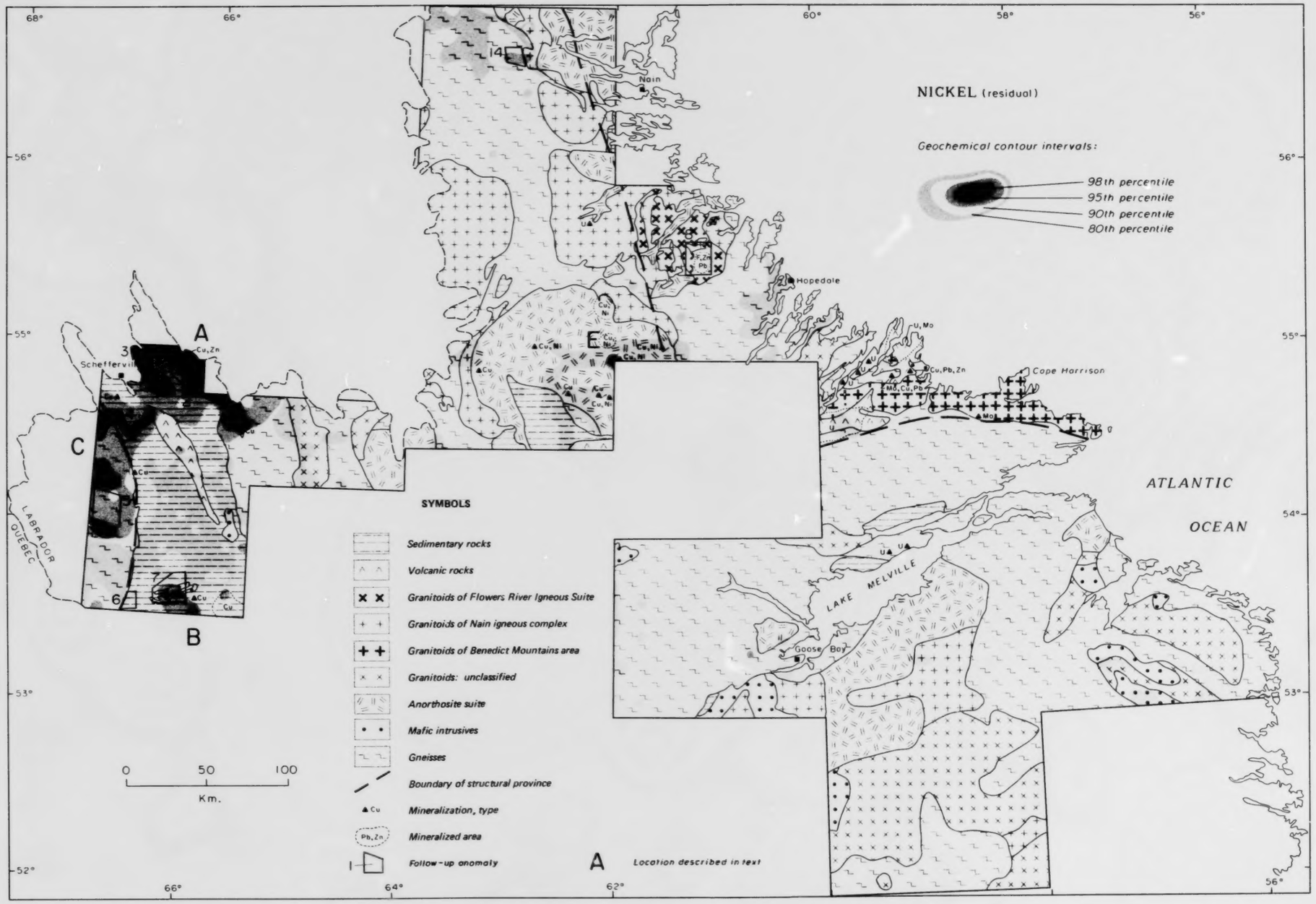
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Location described in text
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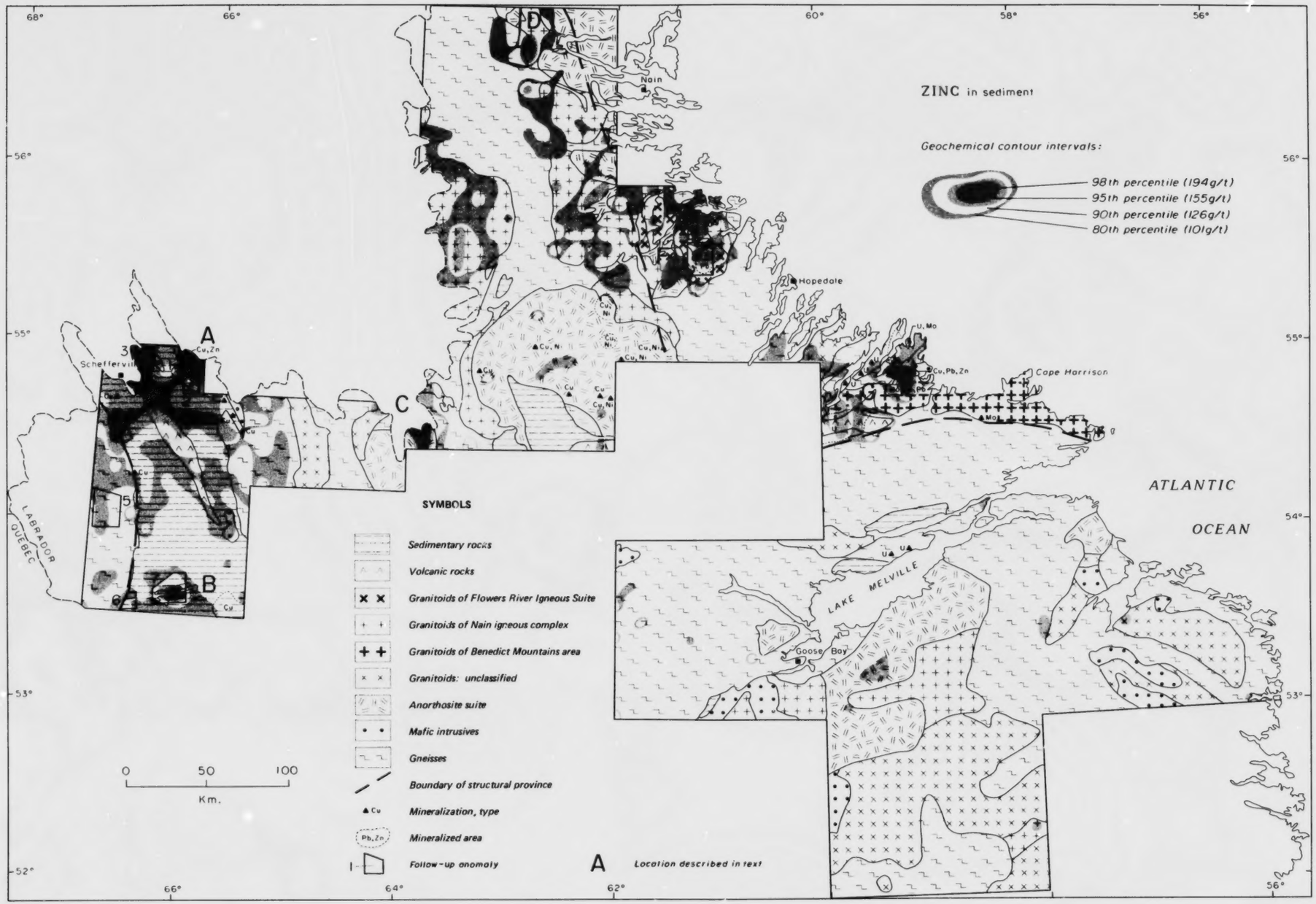
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Volcanic rocks
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Granitoids of Nain igneous complex
Granitoids of Benedict Mountains area
Granitoids: unclassified
Anorthosite suite
Mafic intrusives
Gneisses
Boundary of structural province
Mineralization, type
Mineralized area
Follow-up anomaly
A Location described in text
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Cape Harrison
Goose Bay
LAKE MELVILLE
ATLANTIC OCEAN
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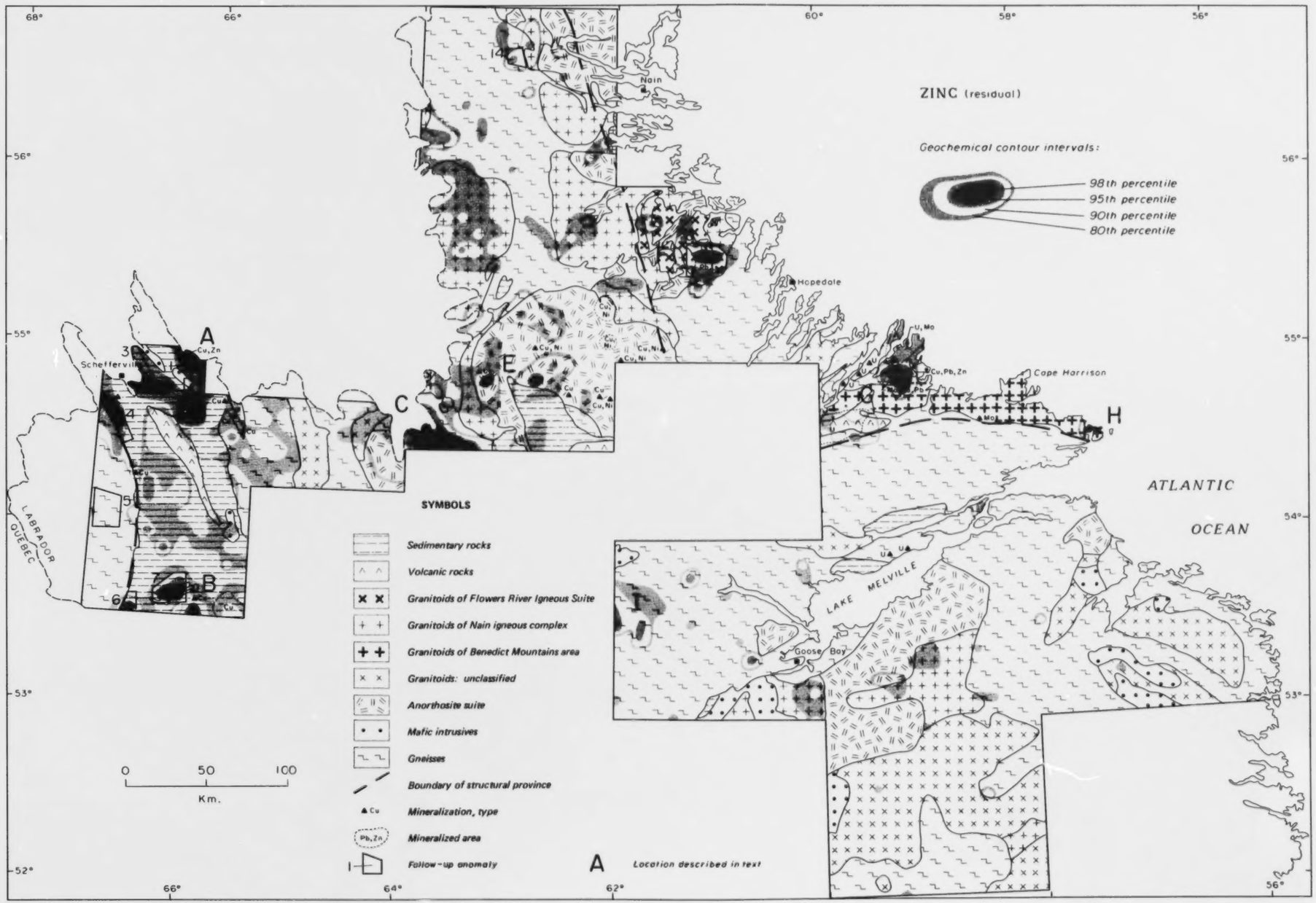
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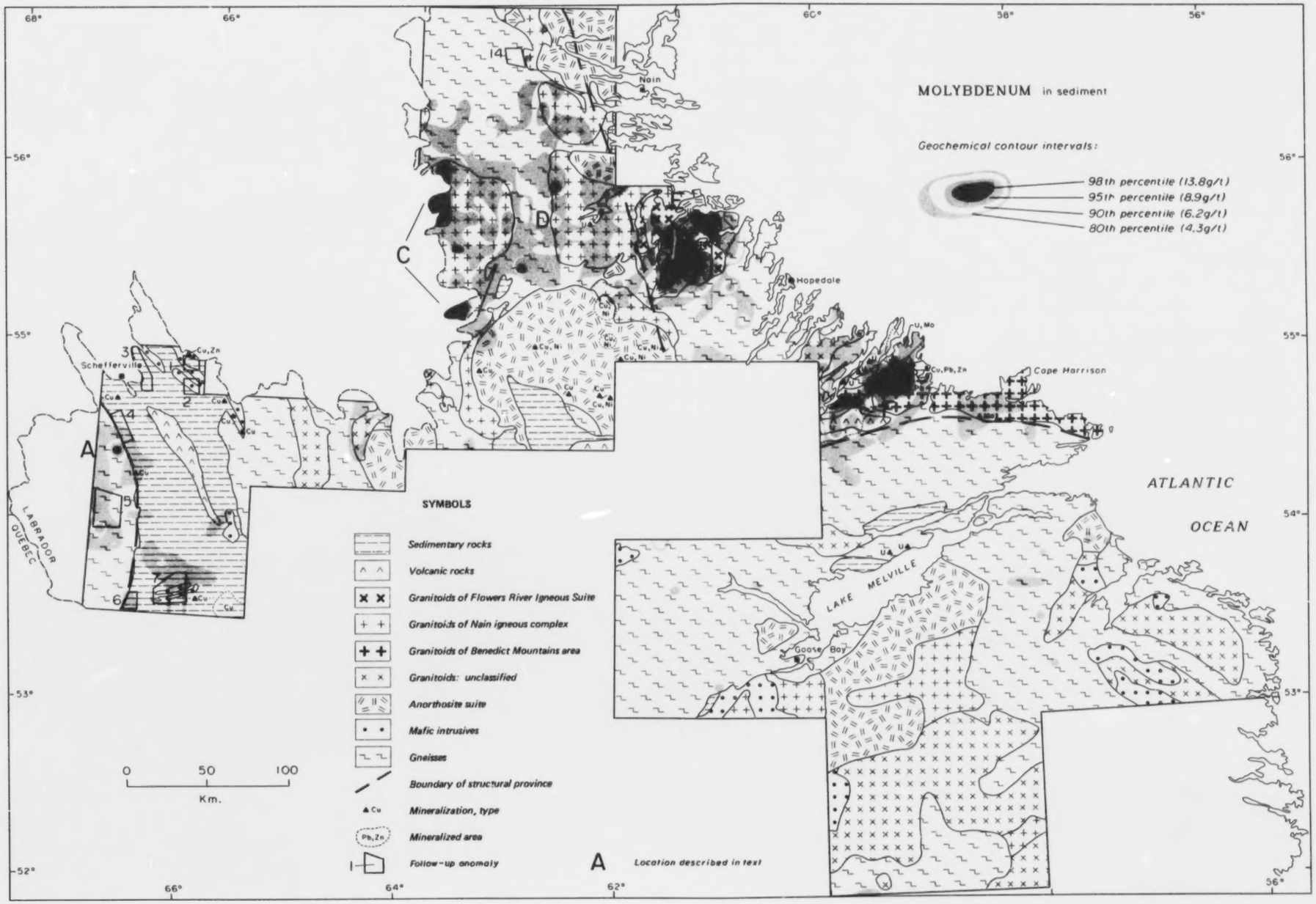
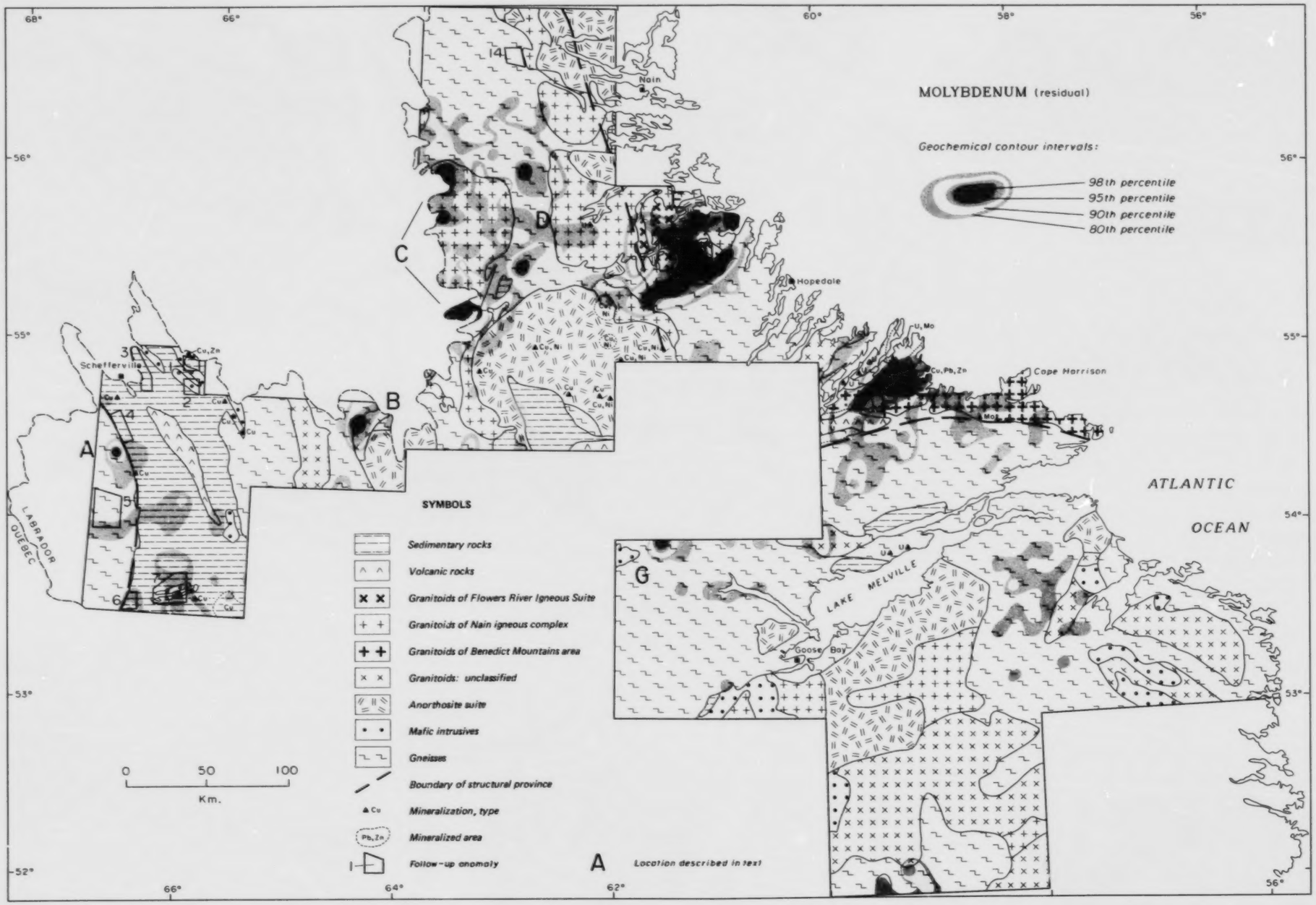
Follow-up anomaly
Location described in text
0 50 100
Km.


MOLYBDENUM in sediment
Geochemical contour intervals:
98th percentile (13.8g/t)
95th percentile (8.9g/t)
90th percentile (6.2g/t)
80th percentile (4.3g/t)
SYMBOLS
Sedimentary rocks
Volcanic rocks
Granitoids of Flowers River Igneous Suite
Granitoids of Nain igneous complex
Granitoids of Benedict Mountains area
Granitoids: unclassified
Anorthosite suite
Mafic intrusives
Gneisses
Boundary of structural province
Mineralization, type
Mineralized area
Follow-up anomaly
A Location described in text
Nain
Hopedale
Cape Harrison
Schefferville
LABRADOR
QUEBEC
LAKE MELVILLE
Goose Bay
ATLANTIC
OCEAN
0 50 100
Km.
68°
66°
60°
58°
56°
55°
54°
53°
52°
64°
62°


MOLYBDENUM (residual)
Geochemical contour intervals:
98th percentile
95th percentile
90th percentile
80th percentile
SYMBOLS
Sedimentary rocks
Volcanic rocks
Granitoids of Flowers River Igneous Suite
Granitoids of Nain igneous complex
Granitoids of Benedict Mountains area
Granitoids: unclassified
Anorthosite suite
Mafic intrusives
Gneisses
Boundary of structural province
Mineralization, type
Mineralized area
Follow-up anomaly
Location described in text
0 50 100
Km.
Nain
Hopedale
Schefferville
Cape Harrison
Goose Bay
LAKE MELVILLE
ATLANTIC OCEAN
LABRADOR
QUEBEC
A
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68°
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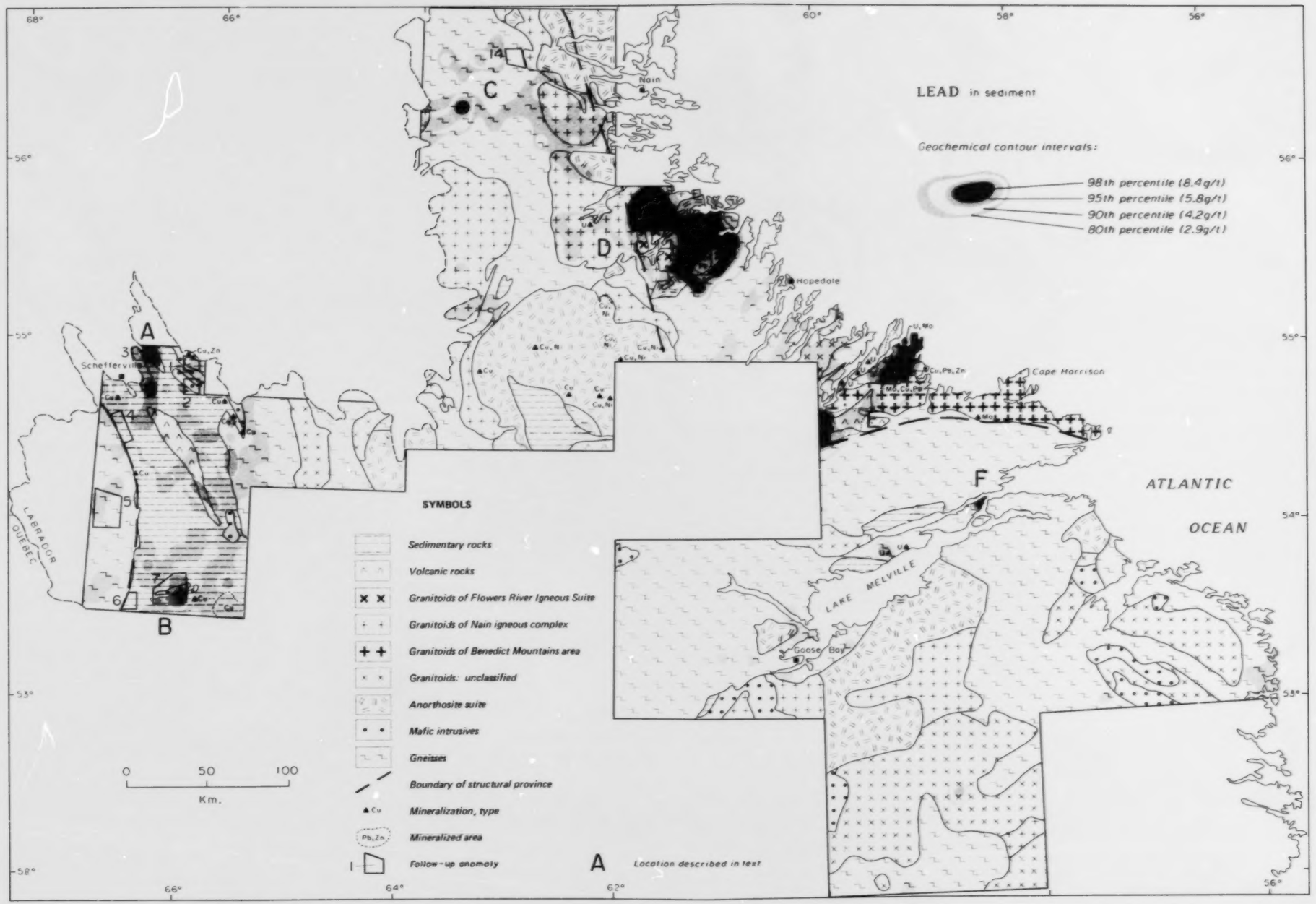
LEAD in sediment
Geochemical contour intervals:
98th percentile (8.4g/t)
95th percentile (5.8g/t)
90th percentile (4.2g/t)
80th percentile (2.9g/t)
SYMBOLS
Sedimentary rocks
Volcanic rocks
Granitoids of Flowers River Igneous Suite
Granitoids of Nain igneous complex
Granitoids of Benedict Mountains area
Granitoids: unclassified
Anorthosite suite
Mafic intrusives
Gneisses
Boundary of structural province
Mineralization, type
Mineralized area
Follow-up anomaly
Location described in text
0 50 100
Km.
Nain
Hopedale
Cape Harrison
Schefferville
LABRADOR QUEBEC
LAKE MELVILLE
Goose Bay
ATLANTIC OCEAN
A
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C
D
F
68°
66°
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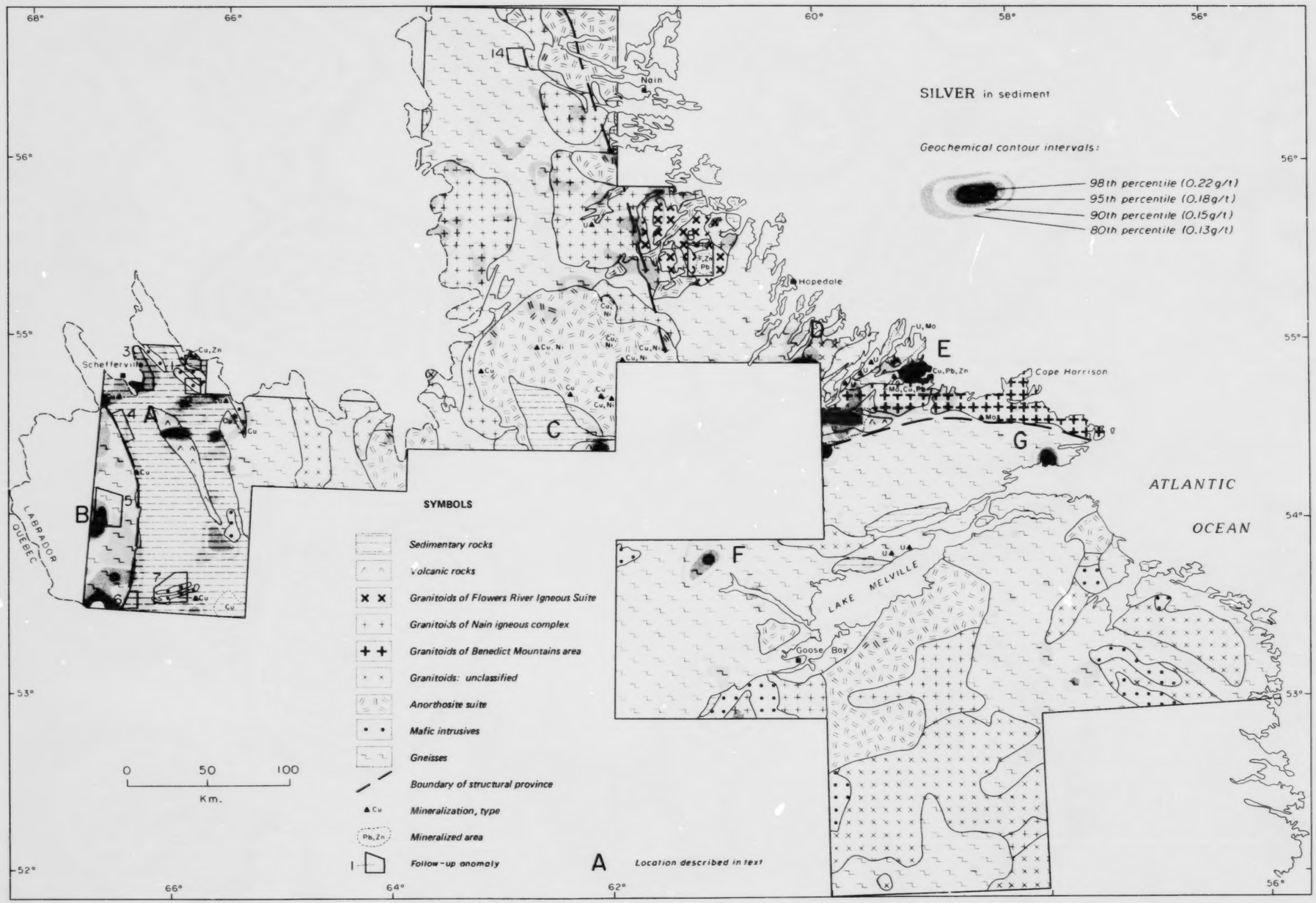
53°
52°
64°
62°


SILVER in sediment
Geochemical contour intervals:
98th percentile (0.22g/t)
95th percentile (0.18g/t)
90th percentile (0.15g/t)
80th percentile (0.13g/t)
SYMBOLS
Sedimentary rocks
Volcanic rocks
Granitoids of Flowers River Igneous Suite
Granitoids of Nain igneous complex
Granitoids of Benedict Mountains area
Granitoids: unclassified
Anorthosite suite
Mafic intrusives
Gneisses
Boundary of structural province
Cu Mineralization, type
Pb,Zn Mineralized area
Follow-up anomaly
A Location described in text
0 50 100
Km.
Nain
Hopedale
Cape Harrison
Schefferville
Goose Bay
LAKE MELVILLE
ATLANTIC
OCEAN
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CHAPTER 3

OUTLINE OF FOLLOW-UP SURVEYS

Introduction

The nine base metal areas selected from within the URP survey to receive follow-up work were chosen using several criteria. These included:

1) the presence of anomalously high levels of base metals in the lake sediments;
2) a favorable combination of anomalous elements;
3) the presence of a geological environment favorable for mineralization;
4) the area be on Crown Land available for staking.

The types of follow-up surveys conducted at each anomaly are summarized as follows:

Table 3-1: Types of follow-up surveys.

Anomaly	Lake Sediment/ Water	Stream Sediment/ Water	Soil	E.M.
1	X	X		
2	X			
3	X	X	X	X
4	X	X		
5	X			
6	X			
7	X			
8	X		X	X
14	X			

Location and Access

The locations of the nine anomalies are shown in Figure 2-1. Anomalies 1 to 4 are accessible from Schefferville, Quebec and Anomalies 5, 6 and 7 are closer to Wabush, Labrador. Anomalies 3 and 4 are accessible by road whereas the others require the use of aircraft, either helicopter or float plane. Both Schefferville and Wabush offer float plane charter service and the nearest helicopter base is in Goose Bay, Labrador.

Currently, Schefferville has regular commercial air service from Montreal and Sept Isles, Quebec. Freight and personnel may be moved to Schefferville via the Quebec North Shore and Labrador Railway from Sept Isles or Wabush. The recent shutdown of the iron mining operation at Schefferville may reduce or eliminate these services. Wabush has scheduled air service to St. John's via Goose Bay and to Sept Isles and Montreal.

The two northern anomalies, 8 and 14, are accessible by float plane or helicopter from Goose Bay. Availability of aircraft fuel at coastal communities such as Nain, Davis Inlet or Hopedale should be verified in advance. Extensive flying in these areas requires fuel caches to be placed in suitable locations.

Physiography

The follow-up areas are located in the James and Davis physiographic regions and are summarized as follows (Bostock, 1970):

Anomaly	Region	Subdivision
1-4	James	Labrador Hills
5	James	Kanipiskau Plateau
6,7	James	Lake Plateau
8,14	Davis	George Plateau

The Labrador Hills area is characterized by northwest trending ridges and valleys reflecting the underlying folded sedimentary and volcanic stratigraphy. Maximum relief at the four anomalies here is approximately 150 m with maximum and minimum elevations being about 625 and 475 m respectively.

Anomaly 5 is in the rugged Kanipiskau Plateau. Relief is about 210 m with a maximum elevation of 730 m.

Anomaly 6 has only about 20 m of relief with the lowest lake having an elevation of 518 m. Numerous small lakes dot the area and drainage systems are very poorly developed.

Anomaly 7 is also in the Lake Plateau but relief is pronounced. Maximum and minimum elevations are 823 m and 502 m but most of the area is below 580 m. The rugged, well drained, higher ground is underlain by Helikian sedimentary and igneous rocks whereas the lower intervening plateau is poorly drained and underlain by Aphebian shale, argillite and graywacke.

Anomaly 8 is in the most rugged region, with 560 m of relief ranging from 590 m to only 30 m above sea level. The terrain of Anomaly 14 is more typical of the physiography of the George Plateau. Most of the area is a plateau which undulates between altitudes of 457 and 579 m. The southern boundary falls off precipitously to Tasisuak Lake with an elevation of only 5 m.

Surficial Geology

All nine anomalous areas were glaciated during the Wisconsin but the effects of the glaciation may vary markedly, even within a given area. Unlike extensive areas of central and southern Canada, this part of Labrador has neither sig-

Table 3-2: Means and log standard deviations of follow-up lake data. Means are expressed in g/t except as noted; all means except LOI and pH are geometric.

Anomaly		1	2	3	4	5	6	7	8	14	Total Data
SEDIMENT:											
Cu	$\bar{x}$	49.3	42.3	70.0	43.7	36.1	18.5	23.7	13.1	72.6	31.1
	σ	(.154)	(.160)	(.241)	(.215)	(.207)	(.211)	(.212)	(.221)	(.223)	
Pb	$\bar{x}$	3.75	2.89	7.81	4.30	2.22	2.40	4.51	8.26	1.94	3.89
	σ	(.303)	(.376)	(.222)	(.335)	(.275)	(.351)	(.406)	(.593)	(.226)	
Zn	$\bar{x}$	196	113	329	242	68.1	164	113	163	129	138
	σ	(.414)	(.221)	(.293)	(.268)	(.169)	(.379)	(.334)	(.390)	(.162)	
Co	$\bar{x}$	13.9	8.03	7.76	4.12	13.2	3.01	3.63	3.87	19.6	6.31
	σ	(.349)	(.266)	(.278)	(.318)	(.283)	(.294)	(.341)	(.404)	(.284)	
Ni	$\bar{x}$	49.3	37.1	43.6	36.1	47.1	24.5	26.5	8.79	59.2	29.9
	σ	(.201)	(.139)	(.209)	(.175)	(.198)	(.346)	(.171)	(.154)	(.272)	
Ag	$\bar{x}$	0.23	0.41	0.58	0.21	0.25	0.17	0.16	0.13	0.24	0.21
	σ	(.207)	(.305)	(.214)	(.299)	(.248)	(.231)	(.245)	(.217)	(.190)	
Mn	$\bar{x}$	303	225	198	209	139	165	112	102	154	147
	σ	(.323)	(.369)	(.425)	(.666)	(.412)	(.522)	(.460)	(.576)	(.228)	
Fe(%)	$\bar{x}$	3.67	2.54	1.88	1.68	1.46	1.90	0.89	1.11	2.94	1.51
	σ	(.367)	(.259)	(.309)	(.368)	(.310)	(.428)	(.307)	(.469)	(.184)	
Mo	$\bar{x}$	4.16	3.10	3.40	4.76	5.40	8.49	3.65	15.3	4.02	5.33
	σ	(.244)	(.234)	(.273)	(.279)	(.269)	(.383)	(.298)	(.564)	(.262)	
F	$\bar{x}$	273	224	240	176	123	71.6	64.6	252	506	150
	σ	(.205)	(.336)	(.258)	(.225)	(.290)	(.364)	(.397)	(.311)	(.128)	
LOI (wt %)	$\bar{x}$	41.2	29.2	31.1	39.1	31.4	40.5	39.9	26.6	15.9	33.0
	σ	(17.8)	(11.5)	(11.0)	(18.4)	(8.2)	(13.8)	(12.4)	(11.7)	(7.39)	
Depth (m)	$\bar{x}$	2.0	3.1	2.6	1.9	4.4	1.6	2.3	4.3	6.5	3.0
	σ	(.353)	(.292)	(.283)	(.277)	(.315)	(.296)	(.355)	(.351)	(.345)	
WATER:											
Heavy Metals (µg/L)	$\bar{x}$	3.79	5.18	7.19	3.42	3.21	2.28	2.45	2.16	1.08	2.79
	σ	(.334)	(.282)	(.340)	(.235)	(.268)	(.183)	(.267)	(.425)	(.120)	
Zn (µg/L)	$\bar{x}$	4.63	4.17	6.50	3.49	4.13	3.0	3.93	3.88	3.76	4.03
	σ	(.325)	(.297)	(.344)	(.235)	(.288)	(.244)	(.302)	(.332)	(.226)	
pH	$\bar{x}$	6.13	6.97	6.83	6.89	6.28	7.19	7.09	6.43	6.47	6.70
	σ	(.806)	(.703)	(.363)	(.337)	(.359)	(.243)	(.463)	(.455)	(.345)	
Sample Sites		19	18	35	41	74	32	93	61	36	409

nificant glaciolacustrine or marine clay deposits nor a thick mantle of drift from terminal or recessional moraines, the presence of which usually restricts the effective application of conventional geochemical exploration methods. Rather, it is characterized by a veneer of ground moraine, usually of local origin.

The Schefferville area is considered by Prest (1970) to have been the locus of the last center of glaciation during the waning stages of the Laurentide Ice Sheet. As such, it may have marked the most recent disappearance of non-arctic glacial ice east of the Rocky Mountains. Prest estimated that glacial ice was present in Schefferville, over Anomaly 4 in particular, as recently as 6 thousand years ago. Proglacial outwash features are generally absent on Anomalies 1 through 5 and drift cover is thin. One exception is the Howells River valley running through Anomaly 4 where the topographic depression trapped a moderate thickness of drift.

Anomaly 6 is transected by two large esker complexes which overlie what appears to be a moderate thickness of glacial outwash sand. Of the nine areas, the geochemical interpretation of this anomaly is probably affected most by glaciation.

The lower elevations of Anomaly 7 also have moderate drift cover whereas the higher areas have a till veneer with numerous bedrock exposures.

Surficial geology at Anomaly 8 is largely topographically controlled with considerable drift cover in the valleys and thinner till coverage on the uplands.

No ground work was done at Anomaly 14, but, as viewed from the air while sampling, a considerable portion of the area displays outcrop with only a thin veneer of till.

Statistical Summary of Follow-up Lake Data

Table 3-2 lists for each anomaly the means and standard deviations of the analytical data. All data except those for pH and LOI were log-transformed prior to calculations. Note that the means for total heavy metals and Zn in water are not strictly comparable because of different analytical detection limits.

CHAPTER 4

FOLLOW-UP SURVEYS IN THE LABRADOR TROUGH

Introduction

Because of similarities in geochemistry and geological settings, the Labrador Trough anomalies (1-4, 6 and 7) are considered separately from the anomalies outside the Trough. Since many base metal occurrences are known in the region and since the geology is better understood than in much of Labrador, the nature of nonferrous base metal mineralization and exploration is first discussed in some detail. The general characteristics and structure of the lake sediment and water data are then evaluated and, finally, the individual anomalies are discussed in terms of the various types of surveys.

Base Metal Mineralization

Introduction

Exploration for nonferrous base metal deposits in the Labrador Trough extends back at least to the mid-1930's. Since then many sulfide occurrences have been found and examined to varying degrees. No occurrence has been discovered to date which can be considered an orebody. Exploration methods applied in the search began with basic prospecting and mapping and, particularly during the 1950's and 1960's, made extensive use of the various rapidly developing geophysical tools including magnetometers, electromagnetic devices (EM) and gravity meters. Several deposits were diamond drilled, generally on the basis of geophysical surveys.

Geology of Base Metal Occurrences

Regional Geology

Most known occurrences are from the eastern or igneous zone of the Trough. Nonetheless, the majority are in sedimentary rocks, particularly carbonaceous shale and slate, as well as quartzite and siliceous carbonate rocks. The regional stratigraphic framework is summarized in Table 4-1. Reference to this table should prove helpful in understanding the geologic context of the individual base metal occurrences described below.

Mineralization

Most of the sulfide deposits may be broadly classified as one of three types:

1) Disseminated mineralization in sedimentary rocks. Such mineralization ranges from weakly disseminated to massive with sulfides composing more than 50% of the rock. The most abundant sulfide is pyrite or pyrrhotite. Low values of Cu and, less frequently, Zn or Pb may accompany the iron sulfides.

2) Disseminated mineralization in igneous rocks. As with the above deposits, mineralization varies from scattered blebs to massive. Similarly, the chief sulfide constituent is pyrite or pyrrhotite with low values of Cu and, rarely, Ni.

3) Vein or fracture fillings. Occurrences of this type are known in sedimentary, volcanic and intrusive rocks. In one variety, sulfides are disseminated in quartz-carbonate veins which, at least in some instances, have been interpreted as infillings of tension fractures associated with folding. Other modes of mineralization in this category are sulfide smears and flakes along joint planes and cleavages. Copper is the usual base metal constituent, but in the Frederickson Deposit, located 3 km east of the Labrador border in Quebec, a deposit of moderately low tonnage grades 7% Zn, 1.3% Cu and 0.5% Pb with associated gold and silver (Dugas, 1970). This deposit occurs as fracture fillings in a gabbro body in contact with slate of the Menihek Formation.

The characteristics of 17 base metal occurrences and groups of occurrences are tabulated in Table 4-2. These represent most of the significant base metal sulfide deposits in the Labrador portion of the Trough associated with sedimentary and volcanic rocks of the Knob Lake or Doublet Group or with gabbros of the Montagnais Intrusive Series. Consideration of this table in conjunction with Table 4-1 suggests at least three significant points.

Firstly, there is a strong spatial relationship between sedimentary rocks intruded by gabbro and base metal mineralization. Areas underlain by sedimentary or volcanic rocks without associated gabbro intrusives have few known base metal occurrences.

Secondly, deposits are largely restricted to a small portion of the stratigraphic section. Most are associated with sediments of the Menihek Formation, or with sediments and volcanics of the overlying Doublet Group. An exception is the vein type occurrence at Breslauer Lake which is in carbonate rocks of the Denault Formation and is remote from the area of intense gabbro intrusive activity.

Thirdly, Cu is by far the most commonly encountered base metal with Zn and Pb respectively trailing in significance. There are also cases of anomalously high Ni values. Nonetheless, the deposit of this type which comes closest to being commercially exploitable, the Frederickson Deposit referred to above, is Zn-rich, with 7% Zn vs. 1.3% Cu.

Origin of Deposits

There is no consensus on the origin of these deposits but clearly they are varied. Early workers viewed nearly all deposits as epigenetic replacements related to igneous intrusions, particularly the Wakuach gabbros. The chief control on mineralization was thought to be the permeability of the various sedimentary and volcanic strata. Current knowledge of stratiform sulfide deposits of sedimentary and volcanic association suggests alternatives. Most of the sulfides are found in sedimentary rocks, particularly black shale and slate; in these rocks, sulfides are intimately associated with thin sedimentary bedding features some of which can be traced for kilometres along strike without showing crosscutting relationships. Such occurrences are more easily explained as being syngenetic depositional rather than replacement deposits.

Other deposits are clearly epigenetic and occur as vein and fracture fillings in a variety of rock types. The origin of yet other deposits is less clear. For example, some consist of segregations of sulfides in gabbros intruding sedimentary rocks. Such mineralization might equally be argued as having a magmatic origin or as representing remobilized sedimentary constituents.

Exploration Methods

In the early years of base metal exploration, mining companies developed an understanding of the stratigraphy and the types of mineralization to be expected in the Labrador Trough. Most exploration has concentrated on the eastern part of the Trough where hundreds of sulfide showings, mostly barren pyrite and pyrrhotite, are marked by prominent gossans. Follow-up exploration of such deposits included ground magnetometer, dip needle, E.M. and gravity surveys and trenching or drilling. Later airborne E.M. and magnetometer surveys were conducted in the search for buried deposits. Again, ground geophysics played the primary role in determining further exploration on a given prospect. Geophysics was successful to varying degrees in outlining subcropping sulfide zones. The success of magnetometer surveys depended on the amount of pyrrhotite present and its magnetic susceptibility. Many barren sulfide showings identified by geophysics were drilled without any attempt at discrimination using geochemistry.

A review of the literature, primarily company and government reports, suggests that because of the remarkable success geophysics was having during this period in discovering orebodies elsewhere in the Canadian Shield, an over reliance was placed on this approach. Geochemistry was still in its infancy, particularly for exploration in glaciated terrain. Judicious application of modern geochemical methods has only recently begun to be applied in the search for these deposits. In later years, minor attention has been paid to rock and overburden geochemistry. Little attention has been paid to multi-element interpretation of overburden geochemistry, nor, apparently, to the nature, depth and provenance of the material sampled. There are few records of stream sediment or water surveys although reconnaissance stream sediment geochemistry had been successfully employed in the Central Mineral Belt as early as 1956 (Brummer, 1960).

Conclusions

Some general observations and conclusions regarding base metal mineralization and exploration in the Labrador Trough should be stressed:

1) Many barren pyrite-pyrrhotite or low grade sulfide deposits of Cu or Cu with minor Pb, Zn and Ni are known. Most are located in the eastern "igneous" zone where pyrrhotite-pyrite-chalcopyrite mineralization is associated with sedimentary and volcanic rocks and gabbro sills.

2) Exploration philosophy to date has emphasized a genetic model in which intrusive mafic rocks are essential to the mineralizing process. Consequently, most exploration effort has focused on the eastern igneous portion of the Trough. Data from lake sediment geochemistry on both reconnaissance and detailed scales suggest that areas underlain predominantly by sedimentary rocks, particularly carbonaceous black shale and slate of the Le Fer and Menihek Formations, may also host sulfide deposits. Several such areas have lake sediments with high concentrations of Zn and, to a lesser extent, Cu, Pb and Ag. Examples of base metal mineralization in similar environments include the MacArthur River and Mount Isa deposits in Australia (Stanton, 1972). The principal host rock for Zn-Pb mineralization in these areas is pyritic carbonaceous black shale dated at 1600 Ma, roughly contemporaneous with the Labrador Trough rocks (1800 Ma). One difference, however, is the presence of mafic tuffaceous units and reworked volcanic detritus in the stratigraphy near the MacArthur River deposit. Only minor mafic volcanism is reported from the western Trough.

3) Hitherto, exploration methodology has stressed prospecting for gossans, careful mapping of selected areas, and airborne and ground geophysics. Geochemical techniques have been largely neglected. Overburden sampling of either soil or till may often provide a rapid method of screening geophysical targets. Sampling of lake and stream sediments and waters, soils and tills might well prove rewarding for both reconnaissance and detailed exploration.

*Table 4-1: Table of formations, Labrador Trough.**

ERA	GROUP OR SERIES	FORMATION, SUITE OR SUBGROUP		ROCK TYPE
		Name	Number**	
Helikian		Shabogamo Intrusive Suite	21	Olivine gabbro, diabase
		Sims Fm.		Quartzite, grit, conglomerate
		Unconformity		
	Montagnais Intrusive Series	Retty Peridotite	20	Peridotite
		Wakuach Gabbro	19	Rhyolite
			18	Glomeroporphyritic gabbro
			17	Gabbro, diabase
		Intrusive Contact		
	Doublet Group	Willbob Fm.	16	Pillow basalt, minor tuff and pillow breccia
		Thompson Lake Fm.	15	Banded siltstone and black slate, chloritic siltstone
		Murdoch Fm.	14	Chloritic and sericitic phyllite; chloritic siltstone, mafic tuff and lava
Aphebian	Upper Knob Lake Group	Tamarack River Fm.	13	Arkose, sandstone, siltstone, mudstone, dolomitic siltstone and mudstone
		Menihek Fm.	12d	Gray pyritic siltstone, quartzite and shale; minor conglomerate, shale and tuff
			12c	Mafic lava and tuff
			12b	Tuffaceous graywacke and siltstone; gray and black slate
			12a	Gray shale and siltstone; black shale
		Sokoman Fm.	11	Cherty iron formation; basal black shale
		Nimish Subgroup	10	Basalt lava interbedded with jasper-bearing volcanogenic conglomerate. Includes numerous thin sills. (Interpolated with Sokoman Fm.)
		Wishart Fm.	9	Orthoquartzite, quartzite, siltstone and minor chert
			9a	Gray, black and white chert; orthoquartzite and minor iron formation
	Lower Knob Lake Group	Fleming Fm.	8	Chert breccia, minor shale and quartzite
		Dolly Fm.	7a	Gray, black and red shale
		Denault Fm.	6	Undifferentiated dolomite
			6b	Massive dolomite; brown laminated and crossbedded dolomite
			6a	Interbedded dolarenite, dololutite and dolomite breccia
		Le Fer Fm. (formerly Attikamagen Fm.)	5c	Gray shale, siltstone and graywacke; partly tuffaceous
			5b	Pillow basalt and tuff
			5a	Gray-green shale and siltstone, thinly bedded and locally dolomitic
		Seward Fm.	4e	Red-gray sandstone; minor algal dolomite
		Unconformity		
Aphebian or Archean			3	Leucogranite, mylonitized granite
Archean	Eastern Basement Metamorphic Complex		2	Granodiorite-tonalite gneiss, locally mylonitized
	Ashaunipi Metamorphic Complex		1	Hypersthene-bearing granitoid gneiss, unseparated felsic intrusives

* After Frarey and Duffell (1964), Greene (1970) and Wardle (1982).

** Refers to formation numbers in Figures 4-6 to 4-12 and 4-17 to 4-21.

Table 4-2: Base metal occurrences in the Labrador Trough (data from Douglas, 1976).

OCCURRENCE NAME	METALS					HOST ROCKS					GROUP OR FORMATION	N.T.S.	MODE OF OCCURRENCE
						Igneous	Sedimentary						
	Cu	Pb	Zn	Ni	Ag	Gabbro or Mafic Volcanics	Shale/ Slate	Quartzite	Carbonate	Not Specified			
Galena Lake	X	X	X		(X)	X					Nimish Volcanics	23I/5	Quartz-carbonate fillings in tension fractures
Andre Lake (3 occur.)	X			(X)		X					Murdoch Fm. & Wakuach Gabbro	23I/12	Disseminated & massive
Andre Island	X					X	X				Murdoch Fm.	23I/12	Disseminated & massive
Montgomery Lake (3 occur.)	X				(X)	X	X	X			Murdoch Fm. & Wakuach Gabbro	23I/12	Disseminated
Fredericksen-Connolly	X						X				Menihek Fm.	23I/13	At sill/slate contact,
Gauthier-Martin No. 6	X						X				Menihek Fm.(?)	23I/13	At sill/slate contact
Moss Lake No. 1-4	X					X	X				Menihek Fm. & Wakuach Gabbro	23I/13	Along slate/gabbro contact
Moss Lake No. 5	X									X	Doublet Group seds.	23I/13	Disseminated in quartz veins
Gauthier Lake	X					X					Doublet Group volcanics	23I/13	Disseminated in quartz veins
Breslauer Lake	X								X		Denault Fm.	23J/10	In quartz veins
Chicago Lake	X						X				Menihek Fm.	23J/16	In shale intercalated with gabbro sills
Jimmick Lake	X	(X)	X				X				Menihek Fm.	23J/16	In shale intercalated with gabbro sills
Martin Lake	X	(X)	X						X		Menihek Fm.	23J/16	Diss. in limestone within slate
N. Martin Lake	X	(X)	X						X		Menihek Fm.	23J/16	Diss. in limestone within slate
Howse Lake (3 occur.)	X							X			Menihek Fm.	23O/1	Along cleavage planes
Howse Lake (2 occur.)	X						X				Menihek Fm.	23O/1	Along cleavage planes
Howse Lake	(X)					X					Wakuach Gabbro	23O/1	Along joint planes

Geochemical Characteristics of Lake Sediment and Water Data

Intervariable Relationships

The correlation coefficients for the Labrador Trough data (238 samples) are listed in Table 4-3. The same conditions of log transformation apply as with the reconnaissance data (see Chapter 2).

The following observations can be made:

1) Moderate to strong correlations occur among Cu, Zn, Co, Ni and F.

2) Mn and Fe correlate strongly.

3) Ag and Cu correlate strongly.

4) Fe correlates moderately to strongly with Cu, Zn, Co, Ni, Mo and F.

5) LOI correlates *negatively* with Cu, Pb, Zn, Co, Ni, Ag and Fe.

6) LOI correlates *positively* with Mo.

7) pH correlates *negatively* with Cu, Pb, Co, Ag, F, heavy metals and Zn in water.

8) pH correlates *negatively* with depth.

9) pH correlates *positively* with Zn and Mo.

10) Depth correlates with Cu, Pb, Ag, Mn, Fe and F.

Table 4-3: Correlation matrix of lake sediment/water data from anomalies in the Labrador Trough. Coefficients between ±0.10 are not significantly correlated at the 95% confidence level. n = 238

		Cu	Pb	Zn	Co	Ni	Ag	Mn	Fe	Mo	F	LOI	Depth	Heavy metals	Zn	pH
Sediment	Cu	1.00														
	Pb	.41														
	Zn	.60	.42													
	Co	.50	.21	.43												
	Ni	.69	.27	.63	.66											
	Ag	.62	.30	.31	.38	.38										
	Mn	.21	−.04	.28	.59	.34	.20									
	Fe	.36	−.03	.43	.65	.41	.27	.76								
	Mo	.03	−.08	.25	.12	.15	.00	.29	.40							
	F	.51	.32	.42	.62	.46	.43	.45	.60	.01						
	LOI	−.12	−.16	−.26	−.19	−.16	−.12	−.01	−.20	.13	−.35					
	Depth	.32	.18	.06	.06	.13	.36	.29	.22	.09	.19	−.08				
Water	Heavy metals	.45	.16	.27	.15	.21	.35	−.05	.03	−.11	.16	−.01	−.05			
	Zn	.26	.25	.27	.11	.16	.21	−.11	−.07	−.13	.07	−.05	−.05	.54		
	pH	−.22	−.12	.13	−.12	−.06	−.28	.05	.07	.18	−.13	−.31	.04	−.28	−.13	1.00

Sediment ← → Water

The relationships noted above cannot be considered in isolation because they reflect the results of several interdependent processes. Nonetheless, correlation analysis helps identify the major processes which affect the dispersion of elements and which are unrelated or only secondarily related to original bedrock composition. If the factors which obscure the detection of primary bedrock or mineralization patterns can be accounted for and minimized, the explorationist is in a better position to evaluate the data.

The correlation of Cu, Zn, Co and Ni (and F to a lesser extent) is probably a reflection of the geochemical similarity of these elements, particularly their similar mobilities in the surface environment.

The strong Fe-Mn and Cu-Ag correlations result from the very similar geochemical tendencies of these two pairs of elements. Mobility of both pairs of elements is strongly controlled at surface by oxidation potential (Eh) and, particularly, by pH. Iron and Mn tend to form insoluble oxides with increasing pH and conversely are quite soluble under more acid conditions. With decreasing Eh (i.e. increasingly reducing conditions), iron oxide becomes more soluble until, with the generation of hydrogen sulfide in the hypolimnion, Fe precipitates as iron sulfides.

Silver and copper are both chalcophile elements and both are soluble under combined acid and oxidizing conditions. Under conditions of increasing pH, Cu (and presumably Ag) precipitates as an oxide. Under conditions of decreasing Eh the elements precipitate first in metallic form and then as sulfides.

Iron as a Control of Trace Element Distribution

The positive correlation of Fe (and Mn) with many elements, particularly Cu, Zn, Co, Ni, Mo and F, is probably a result of the very strong tendency for these ions in solution to coprecipitate with, and to adsorb onto, ferric and manganese hydroxides. These two processes combine to produce what is likely the main influence in altering normal dispersion patterns. The relationship between Mn and these elements was also studied and was found to be so similar to that of Fe that separate consideration is not warranted. The relationship between Fe and the various elements is further examined in Figure 4-1. The plot was obtained by grouping all combined lake sediment/water data from the Trough into equal log-based intervals of Fe. The mean Fe content and the mean value of the various elements were calculated and plotted for each group. To avoid distorting the trends, element values which lay outside $\bar{x} \pm 2.5\sigma^-$ of the entire Trough data set were not included. Limits of $\bar{x} \pm 2.0\sigma^-$ were used for Zn and Mn because of their large variances. All but the two highest Fe analyses (236 of 238

samples) are included. This plot graphically illustrates the relationships measured by the correlation coefficients. Some of the most notable trends are as follows:

1) Ni, Co, Mn, Zn and Mo form the most uniform linear relationships with Fe.

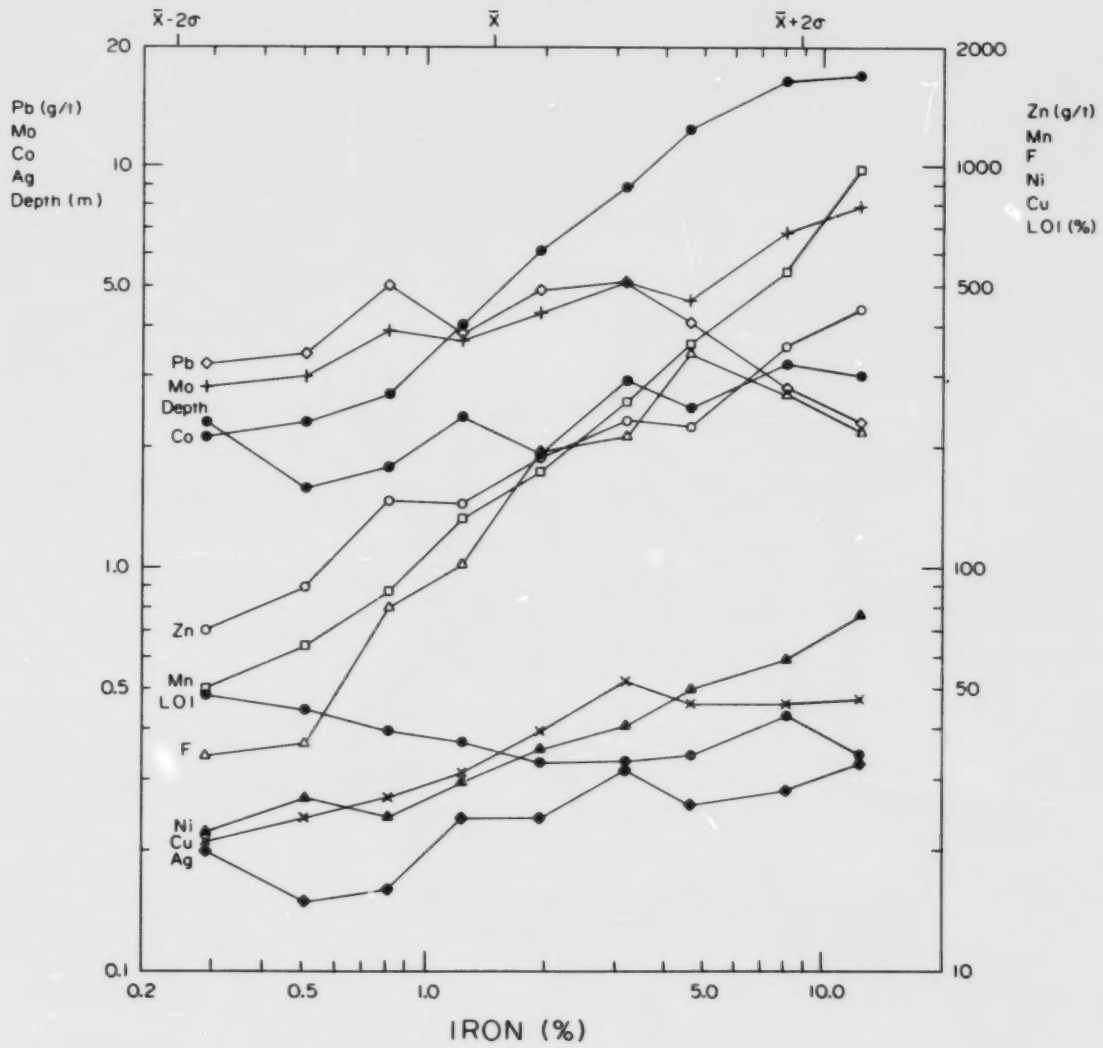
2) Cu (and to a lesser extent Ag) has a very linear trend up to a mean Fe content of 3.2% where it appears to level off.

3) F shows the greatest absolute variation with Fe up to an Fe content of 4.6%. Mean F contents vary from 34 g/t to 350 g/t over this range, a ten-fold increase which appears to be largely attributable to the associated Fe content of the sediment.

4) Pb is the only metal which has a negative slope from low to high Fe although it seems generally positive from 0.3% to 3.2% Fe and then negative with higher Fe contents.

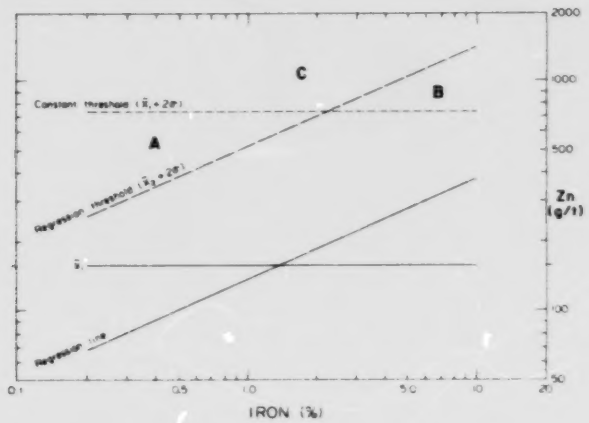
5) LOI declines regularly from very low Fe contents to moderately high Fe contents (3.0%). At higher concentrations the association is irregular. This decrease in LOI with increasing Fe suggests that a decrease in LOI reflects an increase in the oxidation potential of the sediments. That is, sediments enriched in organic material would tend to consume available oxygen more rapidly than organic-poor sediments; thus the latter sediments would more likely provide an oxidizing environment conducive to the precipitation of Fe hydroxides.

Figure 4-1: Relationship between Fe and composition of lake sediment in the Labrador Trough.



The best fit linear regression line of Zn against Fe calculated from these data is plotted in Figure 4-2. For comparative purposes two thresholds have been selected arbitrarily to define samples with anomalously high Zn contents. One is a constant threshold equal to the mean plus 2 standard deviations (740 g/t) of the Zn data. The second threshold varies with the Fe content and corresponds to residual values in excess of 2σ above the regression line. One can readily see that the methods will define two different, but overlapping, populations of samples as being anomalous. Both methods will recognize samples falling in Area C as being anomalous, but the constant threshold method will also classify as anomalous many samples in which the elevated Zn content is attributable to elevated Fe (i.e. Area B). Conversely, it will fail to recognize as anomalous many samples (i.e. Area A) in which the relatively low Zn values may be due to low Fe values.

Figure 4-2: Regression of Zn against Fe, Labrador Trough lake sediment data.



$\bar{x}_1$ = 160 g/t Zn = geometric mean of Zn
$\bar{x}_2$ = mean value of Zn for given Fe content (regression line)

Regression line is based upon the equation:
log Zn = 2.137 + 0.4468(log Fe)

The equation in Figure 4-2 is used to calculate standardized Zn residuals for the data from selected anomalies; maps showing the distribution of these residuals are discussed in detail below, and can be found at the end of this chapter.

Loss-on-ignition as a Control of Element Distribution

To examine further the correlation between LOI and the various elements (Table 4-3), the data from the 238 samples were grouped into classes based on 5% increments of LOI. The mean values for LOI and the various elements were computed for each group and plotted in Figure 4-3. As was done with Fe, extremely high and low values were not included in the calculations. Because there are fewer samples in the extremes of the LOI range, all samples with <15% LOI are considered as one group, samples from 50 to 60% LOI are grouped, and all samples >60% are grouped.

Inspection of Figure 4-3 suggests the following trends:

1) For elements displaying negative correlation coefficients with LOI the negative trend is most pronounced over the central part of the LOI range, from about 20% to 55%.

2) With the exceptions of F and Ni, all elements are notably depleted in the very low LOI group ($\bar{x}$ = 9%) relative to the next higher LOI group.

3) Deviations from the central trend seem, at least partly, to coincide with fluctuations in the depth and Fe parameters.

4) LOI generally increases with decreasing depth.

5) Pb seems less affected by fluctuations in depth and Fe content than do other elements negatively correlated with LOI.

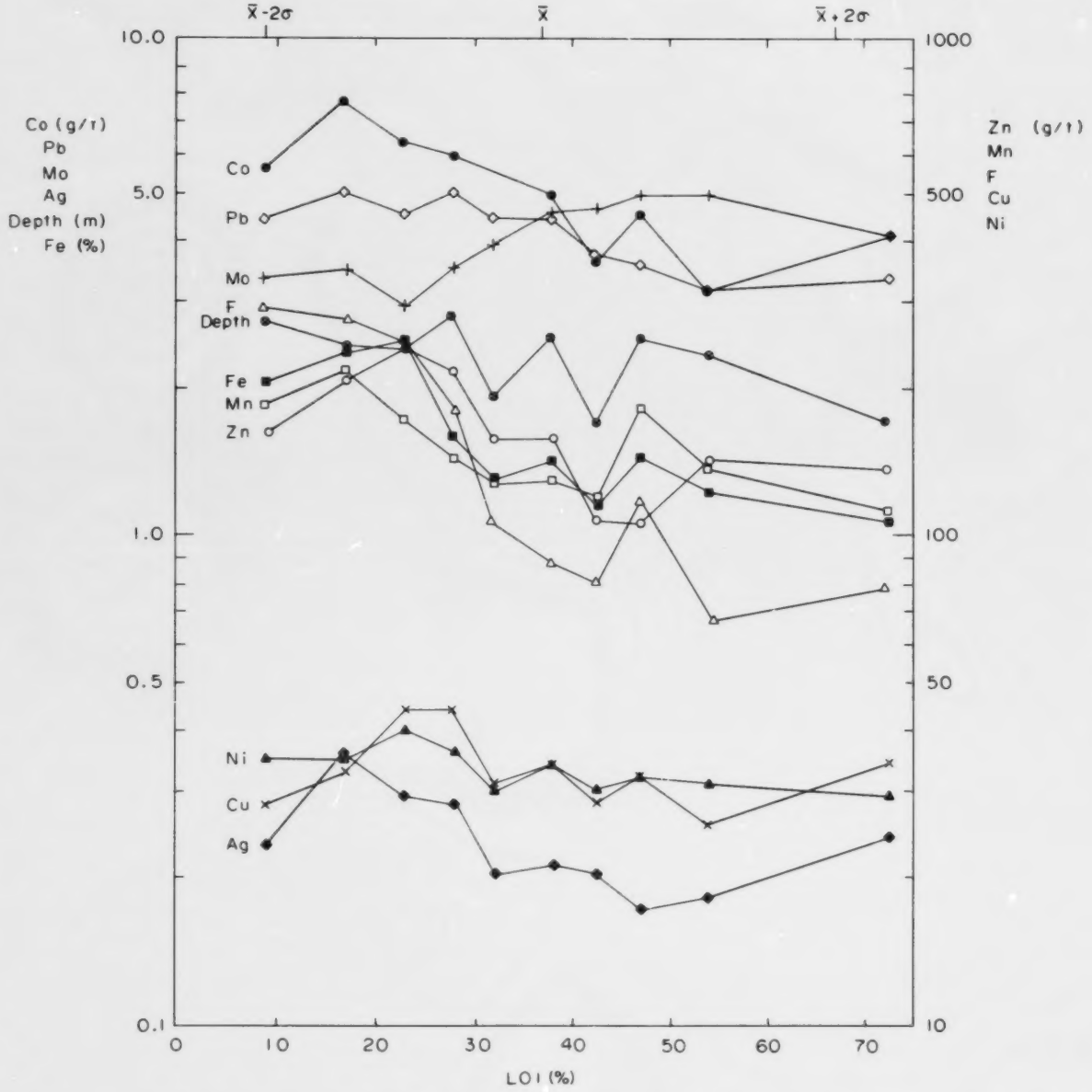
6) Cu and Ag have very similar trends.

7) Mo is a remarkable exception to the general trend revealing a smooth increase with increasing LOI over the range 20 to 45% LOI. At higher LOI values the trend flattens and then declines; the change might be explained by the fact that most sediments with high LOI values are from shallow lakes with low pH and the mobility of Mo in such waters is low.

8) Although Fe and Mn continue their downward trend at >60% LOI, the elements Cu, Ag and Co do not. This suggests that these elements which normally correlate closely with Fe and Mn, presumably by precipitating with or adsorbing onto their hydroxides, will adsorb onto organic matter in the absence of hydroxides and under suitable Eh-pH conditions. Indeed, it seems likely that these trace elements normally adsorb onto the organics but this relationship is masked by their much stronger association with Fe and Mn which correlates negatively with LOI.

One may conclude from these observations that much of the element variation is adequately explained by the variation in Fe. An exception is Mo, the distribution of which seems additionally controlled by LOI. The F content also is influenced strongly by LOI. Other exceptions include Ag and Cu for which depth appears to exert as strong, or stronger, control than does Fe. In all cases multi-element statistical procedures such as stepwise linear or curvilinear regression, might be employed to further explain element variation. If linear regression of Cu, Co, Ag or F against Fe is used

Figure 4-3: Relationship between loss-on-ignition and composition of lake sediment in the Labrador Trough.

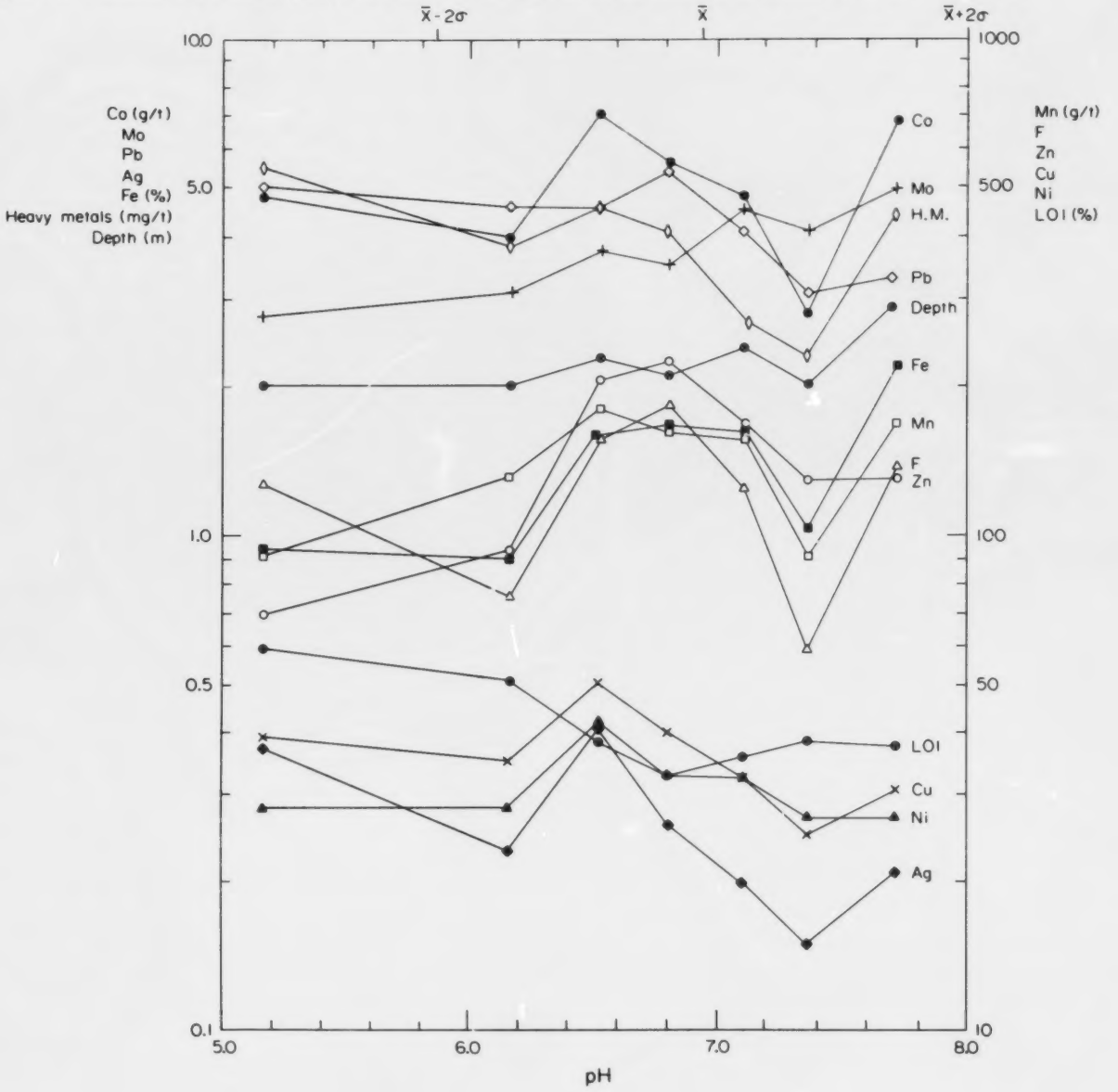


to define anomalous samples, then anomalous samples which have low Fe and very high LOI (greater than about 70%) should be interpreted cautiously.

Water Acidity (pH) as a Control of Element Distribution

The variation of elements with pH, suggested in Table 4-3, is graphically illustrated in Figure 4-4. The data from the 238 samples were grouped by increments of 0.3 pH units except for the low and high extremes of the range where relatively few samples occur. The lowest group includes all samples with pH < 5.8; the next group includes 5.8 to 6.3 pH. The highest group includes all samples with pH > 7.5. It is important to note that the pH measured here represents the condition of the surface lake waters and that pH conditions within the sediments and at the sediment-water interface differ. From Figure 4-4 a number of trends may be noted:

Figure 4-4: Relationship between pH of lake water and composition of lake sediment and water in the Labrador Trough.



1) Several elements behave very similarly, notably Fe, Mn, Pb, Zn, and F; they form a peak in the slightly acid (pH about 6.8) portion of the range and (except Zn) increase sharply in the most alkaline samples.

2) Cu, Co, Ag and Ni behave similarly to the above group except their peak is in more acidic conditions (pH of 6.5). Nickel, like Zn, does not increase in the most alkaline samples.

3) Mo increases quite uniformly throughout the range and has nearly identical fluctuations to those of depth.

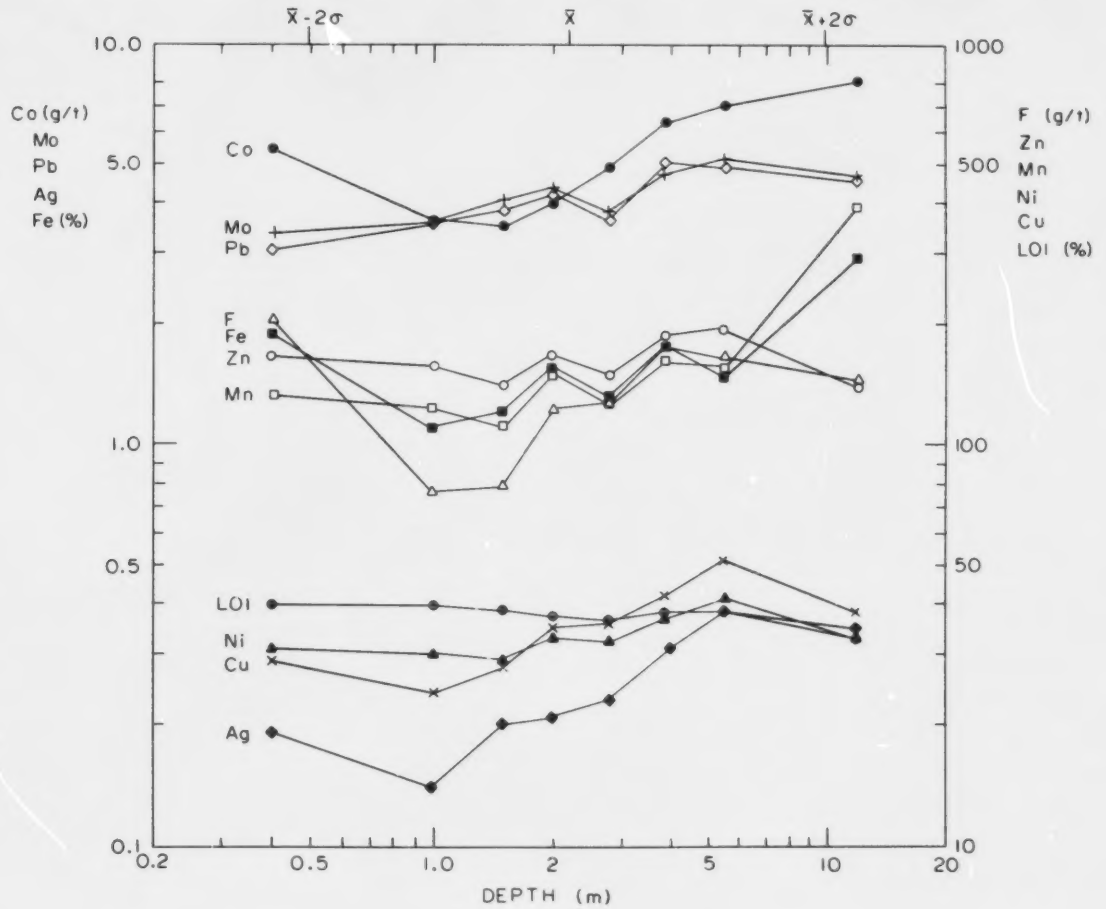
4) The concentration of heavy metals (chiefly Zn) in water decreases continously from a pH of 5.2 to pH 7.4 and then increases sharply in the most alkaline (pH 7.8) group.

5) LOI decreases through most of the acid region and increases moderately in the alkaline range.

The similar trend shared by Fe and Mn with several of the trace elements suggests, again, the strong control that these two elements exert on the dispersion of various trace elements. That the mobility of Fe (and Mn) is strongly pH-dependent is well documented; further evidence for it is seen here. In general, under moderately oxidizing conditions Fe becomes less mobile with increasing pH. The Fe peak seen in Figure 4-4 may be explained then by the increased precipitation rate which accompanies increasing pH; a point would be reached, however, where further increases in pH would result in declining Fe precipitation in sediments because the stream waters draining the catchment basin would be too alkaline to have dissolved and mobilized sufficient iron. The sharp increase in Fe content in the most alkaline group is somewhat surprising; it likely accounts, at least in part, for the moderate increases in Cu and Ag and the sharp increases in F and Co. One explanation is that if these lakes had some Fe-rich acid tributaries, the lakes would be ideal Fe sinks. The increase is partly explained, also, by the fact that the mean depth of this group is 50% greater than that of the immediately preceding pH group. As will be discussed below, the Fe concentration in sediment correlates strongly with depth.

The observed behavior of Zn in sediment and of heavy metals in water may perhaps be explained by the amphoteric nature of Zn. That is, under acid conditions ZnO is soluble to form Zn^{2+}. With decreasing acidity, Zn becomes less soluble until conditions become sufficiently alkaline for ZnO again to become soluble as the zincate ion ($Zn(OH)_4^{2-}$). This property would account for the dramatic increase in heavy metal concentration in the most alkaline waters and the lack of increase in sediment-held Zn in the same group in contrast to most other elements. The implications for exploration in interpreting such data are apparent.

Figure 4-5: Relationship between lake depth and composition of lake sediment in the Labrador Trough.



Lake Depth as a Control of Element Distribution

The positive correlations of many elements with depth is displayed graphically in Figure 4-5. Several trends may be noted:

1) Correlation of elements with depth is particularly strong through the central part of the depth range (1 to 6 m).

2) Zn is exceptional in that it shows little regular variation with depth, although it does vary somewhat in sympathy with Fe except at the extremes of the depth range.

3) Fe and Mn show a pronounced correlation with depth except for the very shallow (<0.5 m) group of nine samples where concentrations of Fe and, to a lesser extent, Mn are elevated.

4) Except for Co, the mean trace element concentrations of the group of deepest samples decline despite the fact that Fe and Mn concentrations increase markedly.

5) LOI remains nearly constant, declining slightly with increasing depth.

Perhaps the most important implication of this figure is the change in behavior of most trace elements, except Co, at great depths. Most trace elements vary sympathetically with Fe over most of the depth range, hence, regression of elements against Fe should prove useful in removing element variation unrelated to provenance. Regression analysis performed on samples obtained from abnormally deep lakes (>6.0 m), however, may give misleadingly low results. Thus caution should be exercised in interpreting data from such samples. A possible explanation of the deviation from an otherwise strong Fe correlation would be a shift in bottom conditions from oxidizing to reducing in the deepest lakes. Such a shift could result in a phase change in the Fe precipitate from hydroxide to sulfide, the latter phase being significantly less capable of incorporating large amounts of various trace element cations than the hydroxide phase. Cobalt, however, is an exception being able to substitute in moderate amounts for Fe in pyrite (Deer et al., 1962).

Anomalies 1 and 2

Geology

These two anomalies are underlain predominantly by Aphebian sedimentary rocks of the Upper Knob Lake and Lower Knob Lake Groups, which have been intruded by Aphebian Wakuach Gabbro (Figure 4-6). The distribution of bedrock underlying Anomaly 1 appears simple, with rocks of only three formations outcropping. This apparent simplicity is due perhaps to the severe lack of outcrop in this area (Wardle, 1982). The oldest rocks are shale, siltstone and graywacke of the Le Fer Formation in fault contact with Wakuach Gabbro (see Table 4-1). The gabbro unit, a sill, is in both fault and intrusive contact with tuffaceous graywacke, siltstone and slate of the Menihek Formation which underlies the northern two-thirds of the anomaly.

Three prospects of Cu, Pb and Zn lie within 3 km of the north end of Anomaly 1. The mineralization is in slate and in limestone lenses within slate of the Menihek Formation. Wakuach Gabbro sills intrude the rocks. The Frederickson Deposit, described previously, lies 12 km to the northwest. A small occurrence of bog iron also occurs within Anomaly 1.

The bedrock geology of the area of Anomaly 2 is more complex. The southern part of the anomaly is underlain by clastic and carbonate sedimentary rocks of the Lower Knob Lake Group of which all five formations are represented except the uppermost Fleming Formation. Rocks of this group have been folded into a southeast plunging anticline and are juxtaposed along a fault, against dominantly igneous rocks in the northern half of the anomaly. The latter are mainly mafic pillow basalts and tuff (Menihek Formation) as well as sedimentary rocks of the Le Fer Formation, all of which have been intruded by a thick sill of Wakuach Gabbro.

Lake Sediment/Water Geochemistry

In the reconnaissance survey Anomaly 1 was anomalous in Zn, Ni and As whereas Anomaly 2 was anomalous in As, Ni and Cu. In the follow-up survey, As was not analyzed but the anomalous concentrations of the other elements were confirmed.

In Anomaly 1 the high concentration of Zn in sediment and heavy metals and Zn in lake waters is of particular note. The Zn distribution (Figure 4-6) shows two foci, a single sample (536 g/t) from a lake draining an area of sedimentary rocks of the Le Fer Formation intruded by Wakuach Gabbro, and a pair of samples (1290 and 1014 g/t) from lakes draining an area underlain by the Menihek Formation. The latter anomalous area is substantiated by two analyses of heavy metals and Zn in water (Figure 4-7); water from a small lake upstream from the two lakes with anomalous sediment yielded 100 µg/L heavy metals and 45 µg/L Zn. This was the highest heavy metal value encountered in the entire follow-up survey. No sediment sample could be obtained from this lake. The heavy metal and Zn in water concentrations decrease progressively down-drainage (100—>20 —>2 µg/L heavy metals and 45—>9—>4 µg/L Zn), a pattern not observed in the two sediment samples. This trend may be explained partly by a modest increase in pH down-drainage (Figure 4-8), 5.8—>6.4—>6.5, which would decrease the solubility of Zn, and partly by dilution. If the high Zn and heavy metal values in water do reflect mineralization, the geochemistry of lake waters in this case serves

as a better guide to focusing exploration attention at the follow-up stage, whereas Zn in sediment provides a longer dispersion train and a larger target at the reconnaissance stage.

Standardized Zn residuals, calculated using the equation regressing Zn against Fe (cf. Figure 4-2), are plotted in Figure 4-9. Comparison of the distribution patterns of Zn and Zn residuals in sediment shows them to be very similar in shape, but the residual anomaly is considerably weaker, the core of the Zn anomaly being first order and that of the residual anomaly being only third order. For Anomaly 1, the Pearson correlation coefficient (0.67) between Zn and pH is moderately strong and positive. The significance of this can be seen by comparing the distribution maps of these two variables (Figures 4-6 and 4-8). Conversely, the coefficients between heavy metals and pH (−0.49) and between Zn in water and pH (−0.31) are moderately negative. Together, these observations suggest that the lake water spans a pH range critical to the solubility of Zn, and that proper assessment of the geochemical significance of lake sediment data requires consideration of all three parameters, Zn in sediment, Zn in water, and pH of surface water (or ideally, water in sediment).

The above observations also hold true generally for Anomaly 2 although the correlations are not as pronounced.

Stream Sediment Geochemistry

Six sediment samples were collected at Anomaly 1 from streams draining into and out of the lake with 100 μg/L heavy metals in its water. Two of the six samples had high analyses of Zn (1300 and 1200 g/t), Ni (115 and 162 g/t), and Cu (32 and 75 g/t). The highest Zn sample was from a stream draining into the lake from a bog. The material sampled at this particular site was highly organic (LOI = 90%) with some trapped clastic matter. However, the other high Zn sample, obtained from the stream draining the lake, had a more moderate LOI of 53%. Moreover, correlation coefficients computed for stream sediments from Anomalies 3 and 4 indicate that Zn and LOI are not strongly correlated (0.15) and thus reduce the concern that Zn may be abnormally concentrated by adsorption onto organic matter.

The stream and lake sediment data, together with the lake water data, indicate that an as yet unidentified zinc source is present in the area.

Anomaly 3

Geology

Anomaly 3 is underlain by sedimentary and minor amounts of volcanic rock of the Upper and Lower Knob Lake Groups (Figure 4-10). The oldest rock is shale of the Dolly Formation overlain by quartzite and siltstone of the Wishart Formation. In a few areas the Wishart Formation is overlain by a thin mafic volcanic sequence of the Nimish Subgroup. Several outcrops of basalt are found near Iron Arm on the eastern edge of the anomaly and a thin tuff unit is found in the extreme southwest. In the absence of volcanics, the Wishart is overlain by cherty iron formation of the Sokoman Formation. The youngest rocks and those immediately underlying most of the anomaly are gray and black slate, siltstone and graywacke of the Menihek Formation. The rocks have been folded into a broad anticline, the axial trace of which trends northwest and passes through the center of the lake sediment survey area.

Lake Sediment/Water Geochemistry

In the reconnaissance survey, Anomaly 3 is characterized by high concentrations of Zn, Pb, Cu, and Ni in many of the lake sediments. Of all areas sampled in the follow-up survey, this anomaly has the highest mean concentration of Zn and Ag in sediments and Zn and heavy metals in lake waters; it has the second highest levels of Cu and Pb. Moreover, the trace element concentrations do not appear to have been enhanced by environmental factors: the mean values of Fe, Mn and depth are only slightly above the averages for all Labrador Trough anomalies.

The distributions of Zn and Zn residuals in sediment and Zn in water is shown in Figures 4-10, 4-11 and 4-12. The calculation of Zn residuals, derived by regressing Zn against Fe, was discussed previously (cf. Figure 4-2). The dispersion patterns are generally similar but differ significantly in detail. In general the maximum values occur near the northwest and decrease sharply in all directions except to the southeast where the values decline gradually. Most streams drain to the southeast and the strata strike in this direction. Close inspection of the drainage systems, however, indicates three distinct areas with elevated Zn and Zn residuals. The lake with the highest Zn concentration in sediment (996 g/t) also displays the highest residual Zn and Zn in water values. A second cluster of three sites where the lake sediments are high in Zn is found northeast of Stinson Lake. The raw Zn values here are erratic in terms of drainage direction, but the Zn residuals decline progressively down-drainage. This second area also has associated high Cu values (143, 134 and 115 g/t) unlike the highest Zn area which has more modest Cu concentrations (98, 41 and 73 g/t). Comparison of the distribution of Zn residuals over the different lithologic units indicates that Zn enrichment is strongly associated with the Menihek Formation. Of the 33 sample sites, seven are from lakes draining partly or exclusively non-Menihek Formation rocks; five of these seven samples have negative Zn residuals. Of the 26 sample sites from lakes draining Menihek rocks, only two yielded samples with negative residuals.

In summary, lake sediment and water analyses from Anomaly 3 indicate that samples from lakes over the Menihek Formation have elevated trace element concentrations.

The sediments are particularly enriched in Zn, Cu, Pb and Ag. There are local areas of very high concentrations superimposed on a regionally high background. Elemental distributions do not seem to be strongly affected by variations in Fe and depth.

Stream Sediment/Water Geochemistry

The stream systems selected for sampling in Anomaly 3 were chosen primarily on the basis of high Zn concentrations in lake sediments and waters during the follow-up survey. Stream sediments and waters were sampled at 55 sites; water samples without corresponding sediments were gathered from a few additional sites. The mean values for the various elements, LOI and pH are summarized in Table 4-4.

Table 4-4: Means and standard deviations of Anomaly 3 stream data.

Element	Mean*	S.D.**
Sediment Data		
Cu	70	.27
Pb	9.5	.31
Zn	398	.33
Cd	3.2	.50
Co	13.6	.50
Ni	41	.28
Ag	0.59	.42
Mn	1010	.72
Fe(%)	4.52	.35
Mo	5.3	.38
F	285	.23
LOI(%)	33.2	20.1
Water Data		
Heavy metals (µg/L)	9.1	.42
pH	6.46	.29

* g/t except pH and as noted; geometric means except arithmetic for LOI and pH.

** log values except for LOI and pH.

The distributions of Zn in stream sediments and total heavy metals in waters are shown in Figures 4-13 and 4-14. Inspection reveals that high values of both Zn and particularly heavy metals occur in the central part of the anomaly. High Zn values are confined mainly to two separate drainage systems, one system draining into the lake with the highest concentrations of Zn in lake sediment and heavy metals in water, and a second system in the same stratigraphic horizon to the southeast. The two samples with the highest Zn contents (1790 and 1440 g/t) are adjacent to each other and also have the highest Fe contents (30.0% and 22.4% respectively). The correlation coefficient of Fe and Zn is 0.45 as calculated from the combined stream data set of Anomalies 3 and 4. Standardized Zn residuals were calculated on the basis of linear regression analysis against Fe and were plotted (not shown). The distribution pattern is similar to that of raw Zn with attention again focused on these two drainage systems, although the highest residuals are not from the same samples with the highest Zn analyses.

Distributions of high concentrations of other trace elements are generally more scattered. Those of Ni and Ag are similar to that of Zn whereas that of Cu is quite dissimilar. High Cu values, up to 152 g/t, occur in a stream (the most western within the soil grid) which has only moderately high Zn contents.

To test for variation in metal content in water with variation in stream discharge, two water samples were obtained from two previously sampled sites which had high heavy metal analyses. The resampling was done under flood conditions following three days of heavy rainfall during which time 7.6 cm of rain were recorded at the meteorological station in nearby Schefferville. Streams were overflowing their banks in many places and had discharge rates estimated at 5 to 10 times those present at the time of the original sampling.

The analyses are as follows:

	Site 1	Site 2
Normal Conditions		
Heavy metals (µg/L)	15	35
pH	6.5	6.4
Flood Conditions		
Heavy metals (µg/L)	15	34
pH	6.0	5.8

The results are surprising. In this very limited test: (1) no dilution of Zn content appears to have taken place and, (2) the water under flood conditions appears to be slightly more acidic. The increase in acidity would increase the solubility of Zn in bedrock and tills and perhaps compensate for dilution.

In summary, stream sediment and water geochemistry indicates that several streams within a relatively small part of the larger lake sediment anomaly carry high concentrations of trace elements, particularly Zn and heavy metals. The anomalous samples are all from streams draining rocks of the Menihek Formation.

Soil and Rock Geochemistry

Analyses of heavy metal contents in stream waters, as determined in the 1980 field laboratory, were used to establish the location of a grid for soil sampling in the area of Anomaly 3. A grid 2 km square was laid out with lines cut and chained initially at 400 m spacings aligned perpendicular to the strike of the local strata. Fill-in lines were cut the following year to give a 200 m line spacing over the center of the anomalous area.

The grid area has a generally thin till cover of local provenance estimated to be less than 2 m thick. Soil development has occurred within the upper part of the till, and soil profiles are recognizable at most sample sites. Samples of B horizon material were collected preferentially at 50 m intervals. Peat and bog material was avoided although some samples contained considerable organic matter. Relief is generally subdued except toward the northeast boundary where it reaches a maximum of about 20 m. Drainage is poorly developed and numerous bogs and ponds are present.

The grid area is underlain almost entirely by folded rocks of the Menihek Formation consisting of northwest striking black and gray slate with some minor thin beds of graywacke. Dips range from shallow to vertical. Along the northeast edge is a strip about 100 m wide underlain by cherty iron formation of the Sokoman Formation. Actual outcrop is scarce but frost-heaved rock is found over about 5% of the area.

A total of 310 soil samples were collected over the grid and 25 slate samples were obtained along a profile across strike. Rock samples include both outcrop and frost-heaved material. The geometric means and log standard deviations of the soil and rock analyses are listed in Table 4-5. Analyses are in g/t except as noted.

Table 4-5: Means and standard deviations of Anomaly 3 soil and rock data. (n.a. indicates not analyzed)*

	Soils (n=310)		Rocks (n=25)	
Element	Mean	S.D.	Mean	S.D.
Cu	31	.30	27	.22
Pb	8.4	.21	13.6	.43
Zn	107	.35	90	.21
Co	7.6	.30	5.8	.37
Ni	19	.30	28	.17
Ag	0.37	.51	0.36	.40
Mn	416	.44	n.a.	–
Fe(%)	4.28	.16	n.a.	–
Mo	3.1	.32	5.3	.40
F	452	.17	1020	.10
LOI(%)	10.3	11.7	n.a.	–

* geometric means and logarithmic S.D. except arithmetic for LOI

The trace element concentrations in the soils and rocks are very similar except for Pb and F which are considerably lower in the soils. This similarity, together with the presence of abundant clasts of slate in the till blanket, supports the belief that the till is of local origin and reflects the chemistry of the underlying bedrock.

Several samples of pyritiferous slate were obtained. Pyrite occurs as both disseminations and thin laminae conformable to bedding, and rarely as vein fillings. The pyritiferous samples do not carry significant amounts of trace metals.

The correlation coefficients for the soil data were calculated for the analytical variables using log-transformed values except for LOI. Manganese, and to a lesser extent LOI, has a very strong positive correlation with some of the trace elements (Table 4-6).

Table 4-6: Partial correlation matrix of Anomaly 3 soil data. Correlation coefficients between ±0.09 are not significant at the 95% confidence level.

	Mn	LOI
Cu	.69	.41
Pb	.13	–.06
Zn	.80	.43
Co	.86	.22
Ni	.82	.36
Ag	.08	.32
Mn	1.00	.33
Fe	.56	–.03
Mo	.54	.43
F	.01	–.34
LOI	.33	1.00

In particular, the distributions of Cu, Zn, Co and Ni seem strongly controlled by the distribution of Mn and, to a lesser extent, by LOI. It should be noted that Mn and LOI are themselves moderately correlated (0.33), an association which accounts in part for the apparently strong correlations of some trace elements with LOI.

Multiple linear regression analysis was performed on Zn against Mn and LOI (Table 4-7). The raw Zn data and the residual Zn data derived from the regression analysis are plotted in Figures 4-15 and 4-16.

Table 4-7: Regression equation of Zn against Mn and LOI in Anomaly 3 soil data.

$$RZn = [LZn - (0.599(LMn) + 0.00565(LOI) + 0.404)] \div \sigma_e$$

where: RZn = standardized residual value of Zn
LZn = log Zn
LMn = log Mn
σ_e = standard error of estimate of regression = 0.204

Examination of the dispersion patterns in the two figures reveals broad similarities and specific differences. Both show trends of high values in the central region roughly parallel to the base line and to the strike of the stratigraphy. The pattern of Zn residuals, however, is more linear and coherent than that of the raw Zn data. The very high isolated Zn values on lines 6E north, 4W south and 6W south which are remote from the central trend are reduced in the residual pattern and appear to belong to lesser linear trends flanking the more intense central one.

Consideration of the Zn analyses in terms of the drainage pattern suggests that many of the very high values occur

in areas of transition from boggy to better drained soil. These areas are probably characterized by an abrupt change in Eh-pH conditions which likely augments precipitation of Mn oxides and their associated trace metals. The distribution of high Zn residuals does not correlate as closely with these transitional environments.

The source of the high Zn values is not known. No Zn analyses of rocks approach those found in the soils. The highest rock analysis (489 g/t Zn) occurs in a sample of frost-heaved slate with quartz veining at 5+65W/1+10N. The sample site is about 40 m from a soil sample moderately enriched in Zn (700 g/t) but very anomalous in residual Zn ($3.27\sigma^{-}$).

The area around 6E between 5+00N and 5+50N was revisited in an attempt to explain the very high Zn values (1050 and 1950 g/t). No explanation was found near 5+00N but a poorly consolidated friable material tentatively identified as bog iron was found and sampled near 5+50N. Analysis of this returned 22% MnO, 36% (Fe_2O_3 + FeO) and 6000 g/t Zn. The highest Zn value (8000 g/t) was from a sample (8+00W/0+50N) collected during the last visit to the area; hence the site has not been examined in detail.

Two explanations for a Zn source are offered. The first is a bedrock source in the grid area as defined by the Zn residuals. Most of the central area is covered by till and bog and it is possible that Zn-rich rocks or mineralization are buried or were not sampled. A second possibility is that the Zn dispersion patterns represent a transported anomaly, evidence for which is given below:

1) The dispersion patterns are linear and although they are parallel to the stratigraphic strike they are also parallel to the direction of ice movement.

2) Although the till is clearly local, it may have been derived from 1 to 2 km up-ice, because of the coincidence of ice movement and strike directions.

3) Additional stream water and stream sediment anomalies (see Figure 4-13) occur along strike and in an up-ice direction from the grid.

In summary, soil geochemistry reveals that anomalous concentrations of Zn occur in an area identified by high levels of heavy metals in stream water. Multi-element data interpretation indicates that the dispersion of Zn in soils is strongly controlled by the dispersion of Mn and by organic content as measured by LOI. Many of the highest Zn analyses are from samples of wad or bog iron. The distribution patterns of the highest Zn values, and even more for those of Zn residuals, are linear and parallel to both the stratigraphic strike and the direction of glacial ice movement. Although the till appears to be of local provenance, no bedrock source for the Zn was identified. It is postulated that such a source exists and either lies hidden within the grid or lies up-ice to the northwest. Geddes (1982) described an anomaly in a till unit in Saskatchewan for which he postulated that the anomalous material was transported englacially for 13 km before being deposited.

Anomaly 4

Geology

Anomaly 4 is underlain entirely by sedimentary rocks of the Labrador Trough (Figure 4-17). From youngest to oldest these include:

1) Menihek Formation – gray and black shale, slate and siltstone
2) Sokoman Formation – cherty iron formation
3) Wishart Formation – chert and quartzite
4) Fleming Formation – chert, breccia, minor shale and quartzite
5) Dolly Formation – gray, black and red shale
6) Denault Formation – dolarenite, dololutite and dolomite breccia
7) Le Fer Formation – gray-green shale and siltstone

The Nimish volcanics were not seen here; further east in the Trough they are found between the Wishart and Sokoman Formations.

The rocks are of very low metamorphic grade and in general dip gently to the northeast. Thrust faulting from the east resulted in frequent repetition of units across strike. The Stakit Lake Fault running northwesterly through the center of the area represents a major structural break along which rocks of the older Le Fer Formation were thrust over the Menihek Formation (Wardle, 1982).

Lake Sediment/Water Geochemistry

Forty-one pairs of follow-up lake sediment and water samples were collected from an area (Anomaly 4) in which high values of Zn and Cu in sediments were recorded in the reconnaissance survey data. The follow-up survey confirmed the Zn anomaly in the area but only a few scattered high Cu values were obtained.

Data maps depicting the distribution of Zn and residual Zn in sediments and Zn in waters are presented as Figures 4-17 to 4-19. The Zn distribution features an isolated first order anomaly (>98 percentile), two scattered second order anomalies (>92 percentile), and a third order anomaly (>85 percentile) which form a broad zone extending from the center to the southeast of the area. A two-sample third order anomaly is also found to the northwest. The distribution pattern of residual Zn (Figure 4-18) differs considerably from that of Zn. Specifically, the first order raw Zn anomaly corresponds to a second order residual anomaly and some of the third order Zn anomalies correspond to fourth order residual anomalies. Conversely, part of the large third order and second order Zn anomaly is upgraded to form a four-sample second order residual anomaly. The isolated first order Zn anomaly in the north may result from

contamination. The shoreline of the pond in question and the drainage area have been disrupted by a road, and high voltage transmission wires stretch across a portion of the pond.

The distribution of Zn in lake waters (Figure 4-19) indicates no pronounced enrichment, with maximum anomalies being third order. The pattern shows poor correlation with that of Zn in sediment; of the eight water samples which are third order anomalies, only three correspond to third order or higher Zn anomalies in sediment. Three of the eight water samples correspond to second order residual Zn anomalies.

Geochemically, there does not seem to be a significant difference in sediment and water composition between samples collected over Le Fer Formation rocks and samples collected from areas draining the Menihek Formation. Of possible significance is the fact that the Stakit Lake Fault is immediately adjacent to the major cluster of anomalous Zn residuals.

Stream Sediment/Water Geochemistry

Samples of stream water, and sediment where available, were collected from a total of 55 sites from Anomaly 4. Samples were collected from areas which had high Zn (and to a lesser extent high Cu) contents in the follow-up lake sediments. In addition, streams draining into Howells River were sampled just upstream of their confluences. This sampling was reconnaissance in nature and was done to acquire data from the Howells River valley which has only a few lakes and hence was largely unsampled during the lake surveys.

The means and standard deviations of the various elements and parameters measured are summarized in Table 4-8.

Table 4-8: Means and standard deviations of Anomaly 4 stream data.

Element	Mean*	S.D.**
Sediment Data		
Cu	62	.27
Pb	11	.33
Zn	282	.32
Co	7.8	.37
Ni	38	.23
Ag	0.46	.34
Mn	1000	.83
Fe(%)	3.21	.44
Mo	6.4	.36
F	423	.27
LOI(%)	34.8	19.6
Water Data		
Heavy metals (µg/L)	2.1	.25
pH	6.62	.34

* g/t except pH and as noted; geometric means except arithmetic for LOI and pH.

** log values except for LOI and pH.

In comparison with Anomaly 3 (cf. Table 4-4), trace element concentrations are moderately lower except for Mo, F and Pb which are somewhat higher. The most significant difference is in heavy metals. Anomaly 3 has a mean of 9.1 µg/L compared with 2.1 µg/L at Anomaly 4.

The dispersion patterns of Zn in sediment and heavy metals in water are shown in Figures 4-20 and 4-21. There is only one sample which constitutes a first order anomaly in Zn (1550 g/t) and this is upstream of the lake having the highest Zn in sediment. It is flanked by samples of low or moderate Zn contents, however, and the associated heavy metals in waters are all low. This sample is extremely enriched in Fe and Mn (29.3% and 7.5% respectively). Since both of these elements correlate quite strongly with Zn, it may be assumed that the high Zn is largely a result of environmental factors and does not reflect Zn mineralization. Indeed, the calculated standardized Zn residual for this sample is only 0.87 standard deviation units above the mean of the residuals.

Only two other samples rank as even third order anomalies in Zn. These are 900 g/t in a sample from a stream draining into Howells River and 800 g/t in a sample from a drainage system south of Howells River. The first sample can be disregarded on the basis of having high content of Fe (11%) and Mn (5.6%). The computed Zn residual is only 0.25 standard deviation units above the mean of the residuals. The second sample is more interesting having associated Fe and Mn contents of only 0.80% and 323 g/t respectively. The computed Zn residual for this sample ($+1.67\sigma^-$) is the highest one calculated for Anomaly 4. This sample is also taken from a site only a few metres downstream from the highest heavy metal in water sample (30 µg/L). In addition, it is located near the center of the largest cluster of lake sediment samples with anomalous residual Zn scores. Nevertheless, the absence of nearby stream samples with supporting high Zn contents and the proximity of a road with its attendant possibility of contamination discounts its significance as an indicator of Zn mineralization. The plot of heavy metal values reveals a lacklustre dispersion pattern of uniformly low heavy metal values with the single exception described above.

In summary, the stream geochemistry of Anomaly 4 is unpromising from an exploration viewpoint. Most of the high Zn samples can be dismissed on the basis of their high associated Fe and Mn contents. The cause of the 800 g/t Zn in the sample south of the Howells River and that of the adjacent 30 µg/L heavy metal sample cannot be explained, but may be due to contamination.

Anomaly 6

Geology

This small anomaly (70 km^2) is located in the southeast of NTS map area 23G/10. It is covered by a thick mantle of sandy drift and is crossed by two large eskers running north-

south. It is situated in the extreme southwest of the Labrador Trough within a kilometre of gneissic rocks of the Superior Province. Very few outcrops occur in the area which was described by Tiphane (1951) as being underlain almost entirely by gray slate of the Menihek Formation dipping gently to the east. In the southwestern part of Anomaly 6, one lake (of the 32 lakes sampled) is underlain by carbonate iron formation of the Sokoman Formation. The area is located near the northern limit of Grenvillian metamorphism. Unmetamorphosed gray siltstone, considered by Tiphane to be stratigraphically equivalent to the slate, is found 30 km to the north.

Diorite may also occur in the anomaly area; a large outcrop of this rock is located 8 km northeast of the anomaly and is the only outcrop within an 8 km radius. Most nonferrous base metal mineralization in the Labrador Trough is associated with shale intruded by mafic igneous rocks.

Lake Sediment/Water Geochemistry

The reconnaissance survey obtained high values only in Zn (maximum 445 g/t). Of the 32 sediment samples collected during the follow-up survey one analyzed 970 g/t Zn, a first order anomaly, and two others exceeded 500 g/t, second order anomalies. The highest two values were from lakes in the same drainage system 1.5 km apart. None of the three samples has an abnormally high Fe or Mn content nor is from an unusually deep lake; thus these environmental factors appear not to be significant here. Because of the extreme scarcity of outcrop and hence poor geological control, it is difficult to determine whether the lake sediment analyses are reflecting local bedrock composition. Evidence that they are is offered by the observation that the five lakes overlying, or adjacent to, the area mapped as iron formation have substantially lower Zn contents than the 27 lakes overlying Menihek slates. If bedrock composition is being reflected by lake sediment composition, the anomalous samples may be significant and possibly indicate the presence of Zn mineralization. Significantly, recent lake sediment data from the adjacent area indicate that the anomaly extends to the south an additional 10 km with high concentrations of not only Zn but also Cu, Cd, Ag and Hg. Iron and Mn levels are normal (Geological Survey of Canada/Newfoundland Department of Mines and Energy, 1982).

One other factor which likely affects the dispersion of Zn at Anomaly 6 is the alkalinity of the lake waters (mean pH = 7.2). The surface waters here have the most alkaline values encountered in the follow-up survey and reflect the high carbonate content of the local bedrock. Tiphane (1951) noted that carbonate is found both as iron formation (siderite) and as a dolomite unit outcropping to the north within the Menihek Formation. These moderately alkaline lake waters would have the effect of encouraging the precipitation of Zn from solution, thus enhancing the Zn content in the sediments while suppressing the Zn content in the waters. In fact this anomaly has the lowest Zn and heavy metal contents in waters of all the anomalies followed up in the Labrador Trough.

Anomaly 7

Geology

The area comprises roughly 260 km^2 and is located in NTS map area 23G/10 (Figure 2-1). The most recent geologic mapping is by Ware and Wardle (1979). Outcrops are scarce, particularly of rocks of the Upper Knob Lake and Lower Knob Lake Groups which are relatively soft and easily eroded. The anomaly is located at the southern end of the Labrador Trough and near the northern limit of Grenvillian deformation. It is underlain by Aphebian metasedimentary rocks and by Paleohelikian metasedimentary and igneous rocks. Aphebian rocks were moderately deformed and metamorphosed to subgreenschist facies during the Hudsonian Orogeny, and were more intensely deformed and metamorphosed to lower greenschist facies during the Grenvillian Orogeny.

Three Aphebian formations of the Upper Knob Lake and Lower Knob Lake Groups are found. The oldest, slate and phyllite of the Le Fer Formation and cherty iron formation of the Sokoman Formation, underlie only a small area to the southeast. Black slate, phyllite and schist of the Menihek Formation underlie about half of the region. The Evening outlier, consisting of orthoquartzite of the Paleohelikian Sims Formation, is found near the center of the area. All units were intruded by olivine gabbro and diabase of the Shabogamo Intrusive Suite which occur as sheets, sills and dikes. The suite is dated by a Rb-Sr isochron at 1685 ± 60 Ma (Ware and Wardle, 1979), and hence is considered only slightly younger than the Sims Formation. No occurrences of base metal mineralization have been recorded in the immediate area.

Lake Sediment/Water Geochemistry

Ninety-three samples were collected during the follow-up survey of Anomaly 7. Of the analyses, Zn and Pb in sediment show the most anomalous enrichment. Four samples, with Zn contents of 1417, 1220, 880 and 826 g/t, have substantially higher contents than the others, most of which cluster within 100 g/t of the mean value of 113 g/t. Three of these four samples are enriched in Pb (5, 36, 27 and 73 g/t respectively) relative to the anomaly mean of 4.5 g/t. Three of these four lakes are also enriched in Zn in water, having 12, 20, <4 and 11 µg/L respectively. The value of 20 µg/L is the highest encountered at this anomaly. By comparison, 63 of the 93 water samples yielded analyses at or below the detection limit of 4 µg/L. These samples are not notably enriched in other base metals, nor in Fe or Mn. Thus it would appear that these anomalous lake sediment concentrations do not result from environmental factors. Rather, it is likely that they reflect a bedrock source.

The location of these four anomalous lakes relative to the bedrock geology is interesting. In all cases they are found downstream, and within several hundred metres, of the mapped contact between Shabogamo gabbro and metasedimentary rocks of the Menihek Formation although no outcrop is known within a kilometre of any of these lakes. In this respect, the geologic settings of these lakes are similar to those of many base metal occurrences in the northeastern part of the Labrador Trough where mineralization is associated with Menihek Formation slate intruded by gabbro.

Figures 4-6 through 4-21.

LEGEND

Zinc in lake sediment. Anomalies 1 and 2

Geochemical Contours, Zn

97%*		780 g/t
92%		500
85%		350
70%		200
40%		110

Geologic boundary . . . . . .

Fault . . . . . ~ ~ ~ ~

Mineral occurrence . . . . . ✖

Copper . . . . . Cu

Lead . . . . . Pb

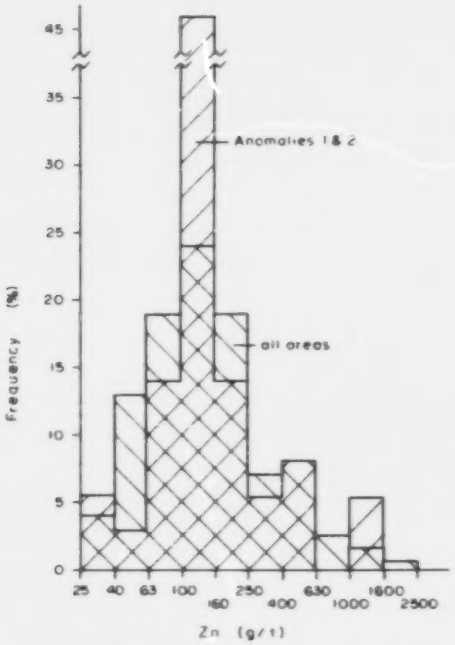
Zinc . . . . . Zn

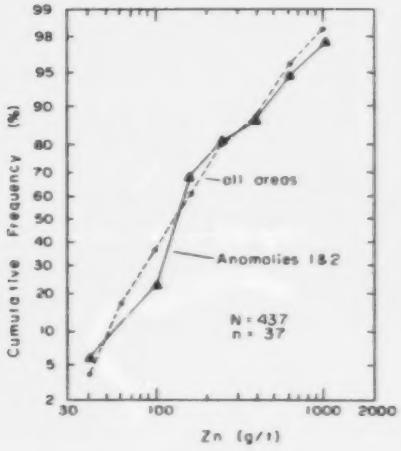
Sulfides . . . . . S

• 536 Zinc in lake sediment, grams/tonne

Elevation in metres above sea level

Bedrock Geology: see Table 4–1 for key





*Percentiles based on total data from 9 follow-up areas.

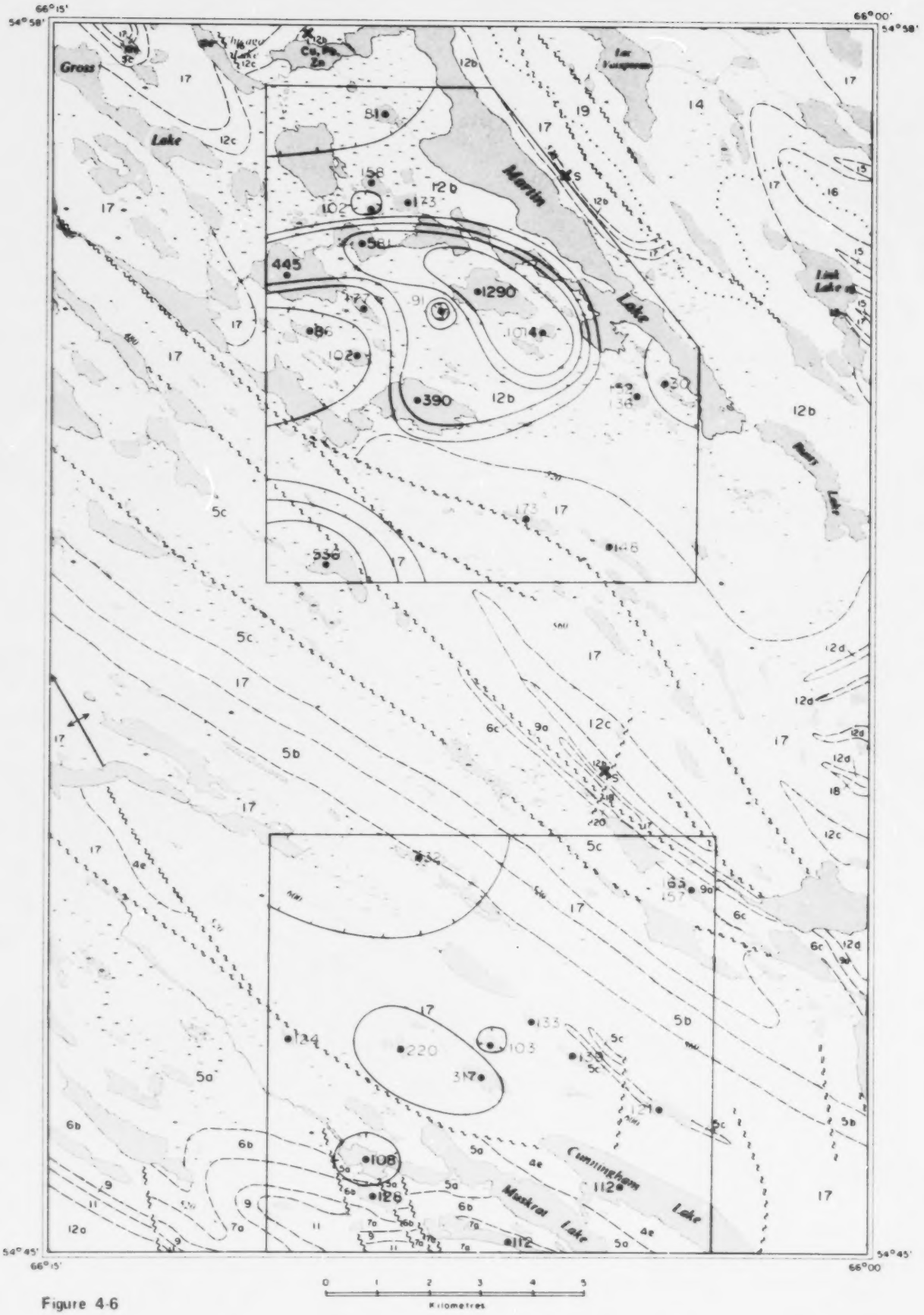

66°15'
54°58'
66°00'
54°58'
Gross
Lake
Cu, Pb, Zn
Lac Pourquoi
Martin
Lake
Link Lake
Mary Lake
445
1290
390
Cunningham
Lake
Muskrat Lake
54°45'
66°15'
66°00'
0 1 2 3 4 5
Kilometres

Figure 4-6

LEGEND

Zinc in lake water, Anomalies 1 and 2

Geochemical Contours, Zn in water

97%*	21	µg/L
92%	12	
85%	8	
70%	6	
40%	4	

Geologic boundary .....

Fault .....

Mineral occurrence .....

Copper ..... Cu

Lead ..... Pb

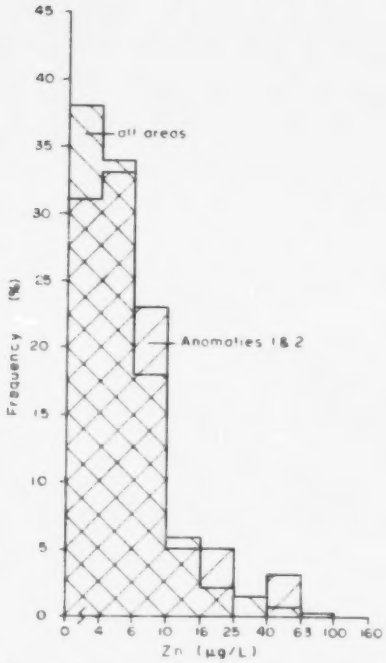
Zinc ..... Zn

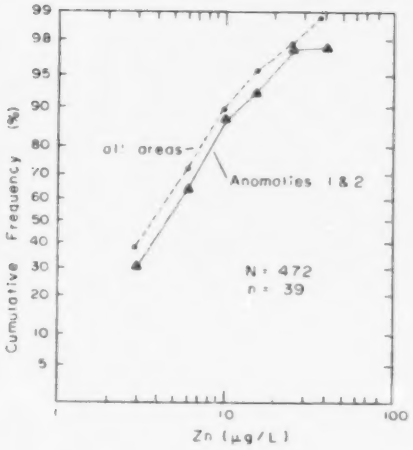
Sulfides ..... S

•5 Zinc in water, µg/L

Elevation in metres above sea level

Bedrock Geology: see Table 4–1 for key





*Percentiles based on total data from 9 follow-up areas.

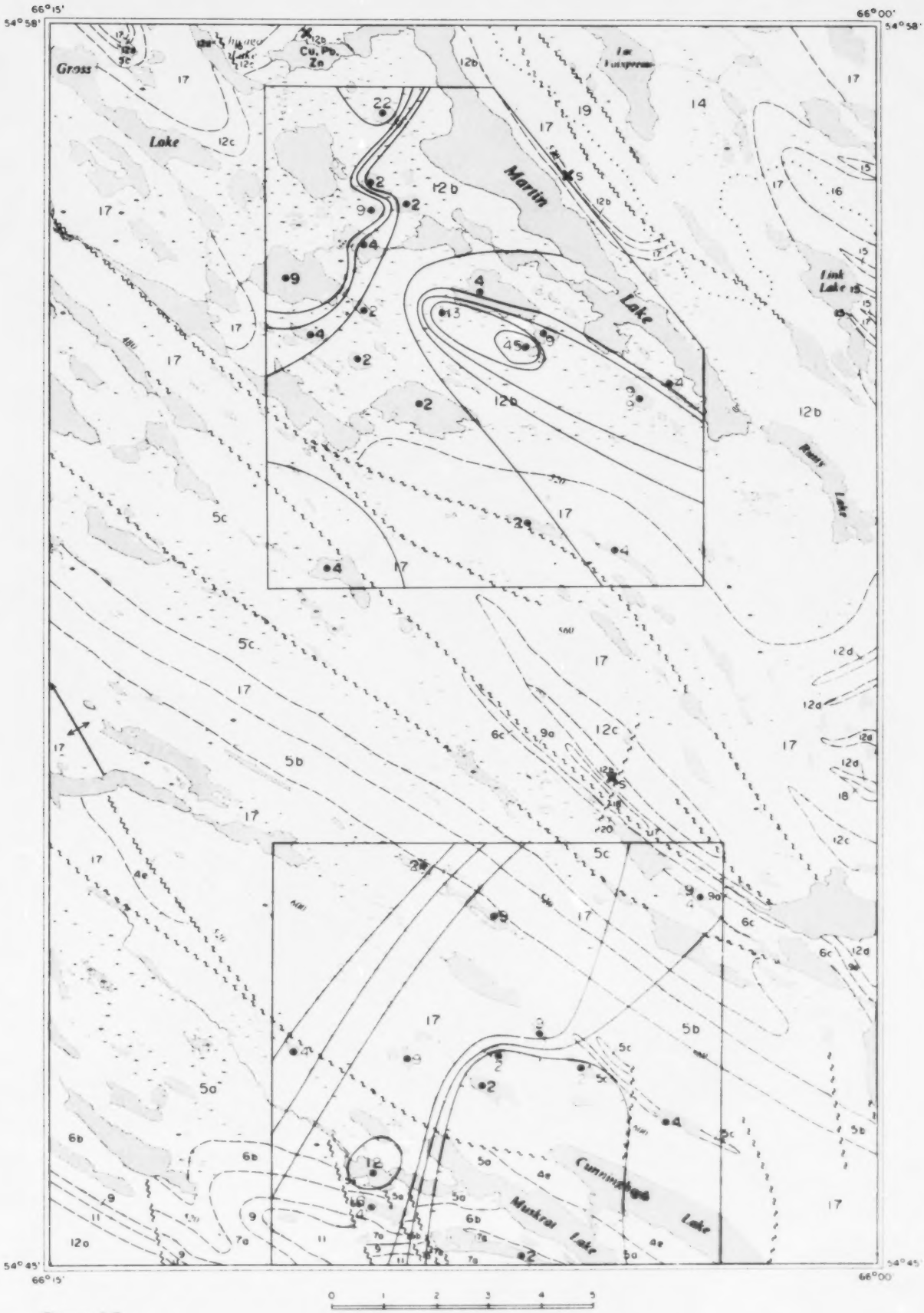

66°15'
54°58'
66°00'
54°58'
Gross
Lake
Cu, Pb,
Zn
Martin
Lake
Link
Lake
Rusty
Lake
Cunningham
Lake
Munroe Lake
54°45'
66°15'
66°00'
54°45'
0 1 2 3 4 5
Kilometres

Figure 4-7

LEGEND

pH in lake water, Anomalies 1 and 2

•6.5 pH of lake water

Geologic boundary .....

Fault .....

Mineral occurrence ..... ×

Copper ..... Cu

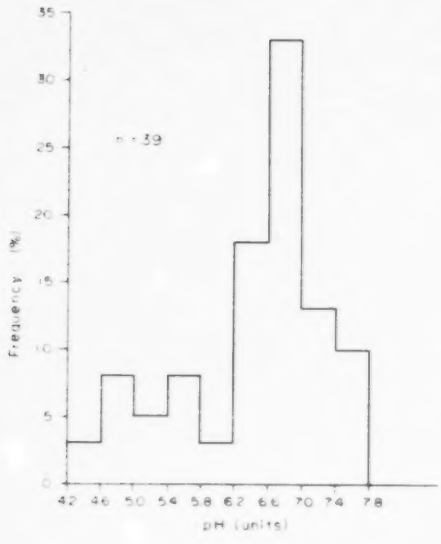
Lead ..... Pb

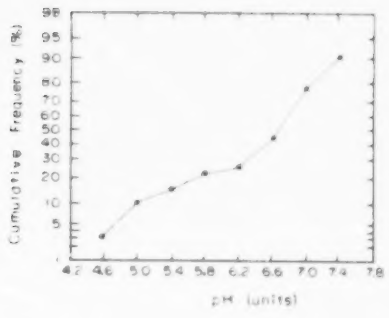
Zinc ..... Zn

Sulfides ..... S

Elevations in metres above sea level

Bedrock Geology: see Table 4–1 for key





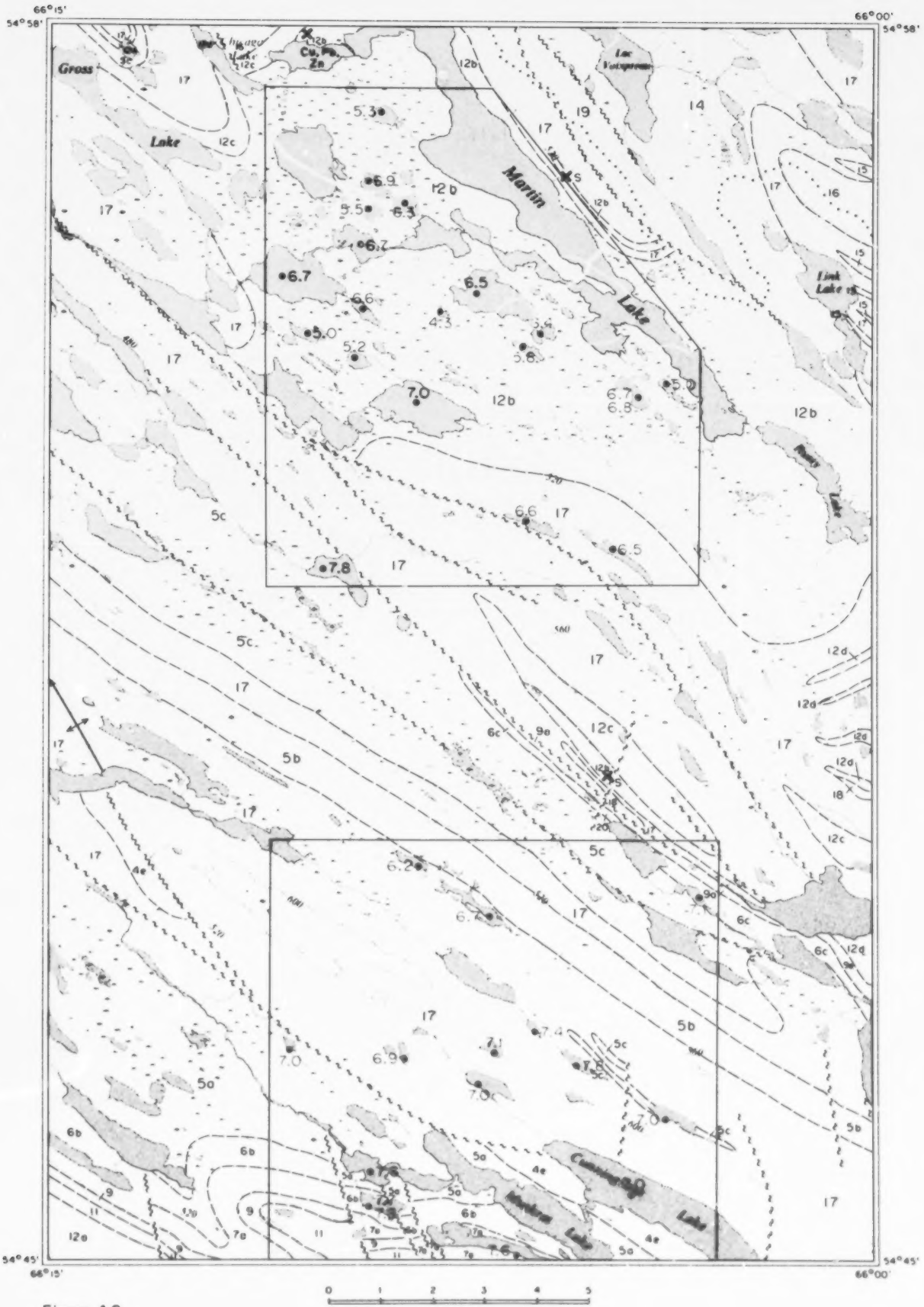

66°15'
66°00'
54°58'
54°45'
Gross
Lake
Martin
Lake
Link Lake
Cummings Lake
Hanbury Lake
Cu, Pb, Zn
0 1 2 3 4 5
Kilometres

Figure 4-8

LEGEND

Residual Zn in lake sediment, Anomalies 1 and 2

Geochemical Contours, Residual Zn

97%*	———	2.20 s.d.
92%	———	1.70
85%	———	1.30
70%	———	0.55
40%	———	–0.40

*Percentiles based on total data from 9 follow-up areas.

• 1.36 Residual Zn in lake sediment, std. dev. units

Geologic boundary . . . . . /———

Fault . . . . . ~~~~~

Mineral occurrence . . . . . ✖

Copper . . . . . Cu

Lead . . . . . Pb

Zinc . . . . . Zn

Sulfides . . . . . S

Elevation in metres above sea level

Bedrock Geology: see Table 4–1 for key

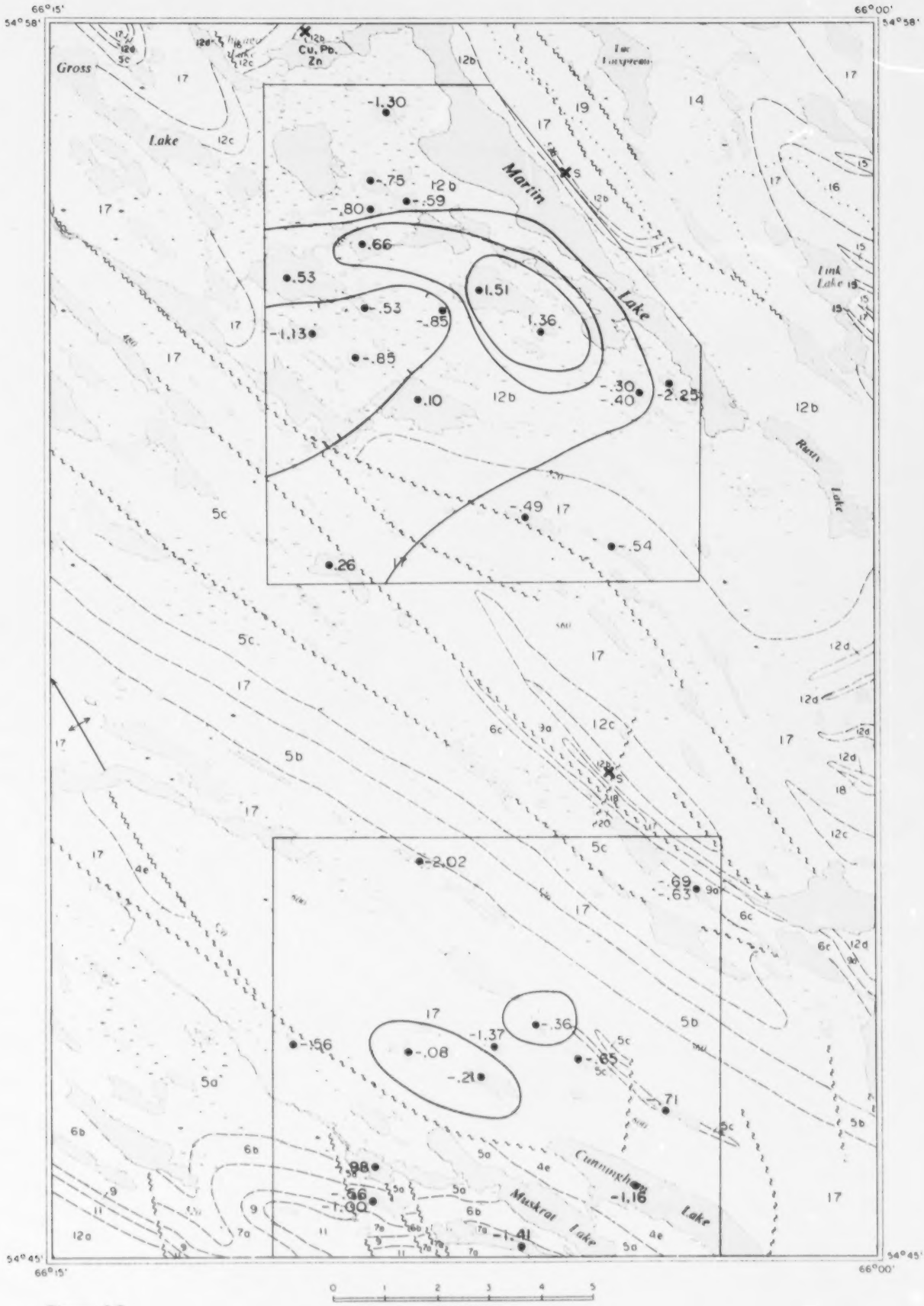

66°15'
66°00'
54°58'
54°45'
Gross
Lake
Cu, Pb, Zn
Martin
Lake
Link Lake
Rush Lake
Cunningham
Muskrat Lake
Lake
-1.30
-.75
-.80
-.59
.66
.53
-.53
-.85
1.51
1.36
-1.13
-.85
.10
-.30
-.40
-2.25
-.49
-.54
.26
-2.02
-.69
-.63
-.36
-1.37
-.56
-.08
-.21
-.85
.71
.98
-.56
-1.00
-1.16
-1.41
0 1 2 3 4 5
Kilometres

Figure 4-9

LEGEND

Zinc in lake sediment, Anomaly 3

Geochemical Contours, Zn

97%*		780 g/t
92%		500
85%		350
70%		200
40%		110

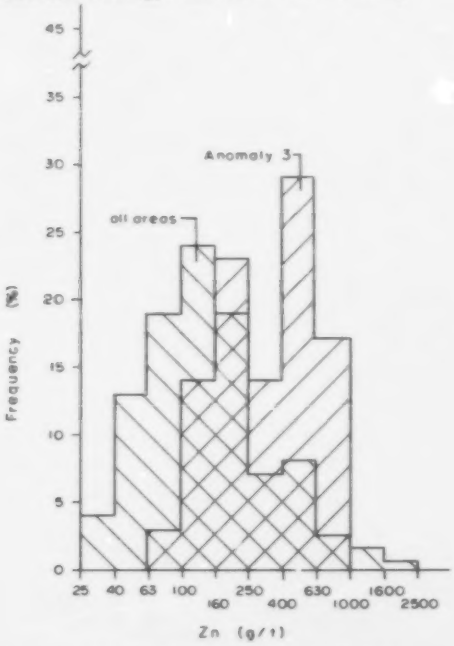
Geologic boundary .....

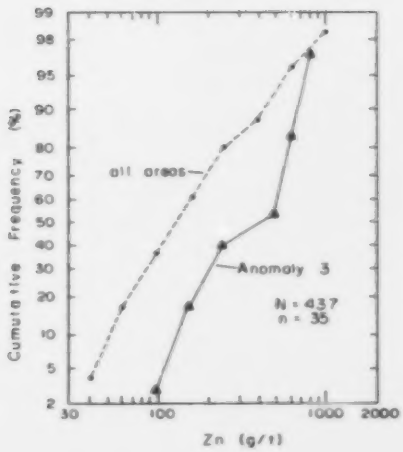
Fault.....

• 8 Zinc in lake sediment, grams/tonne

Elevation in metres above sea level

Bedrock Geology: see Table 4–1 for key





*Percentiles based on total data from 9 follow-up areas.

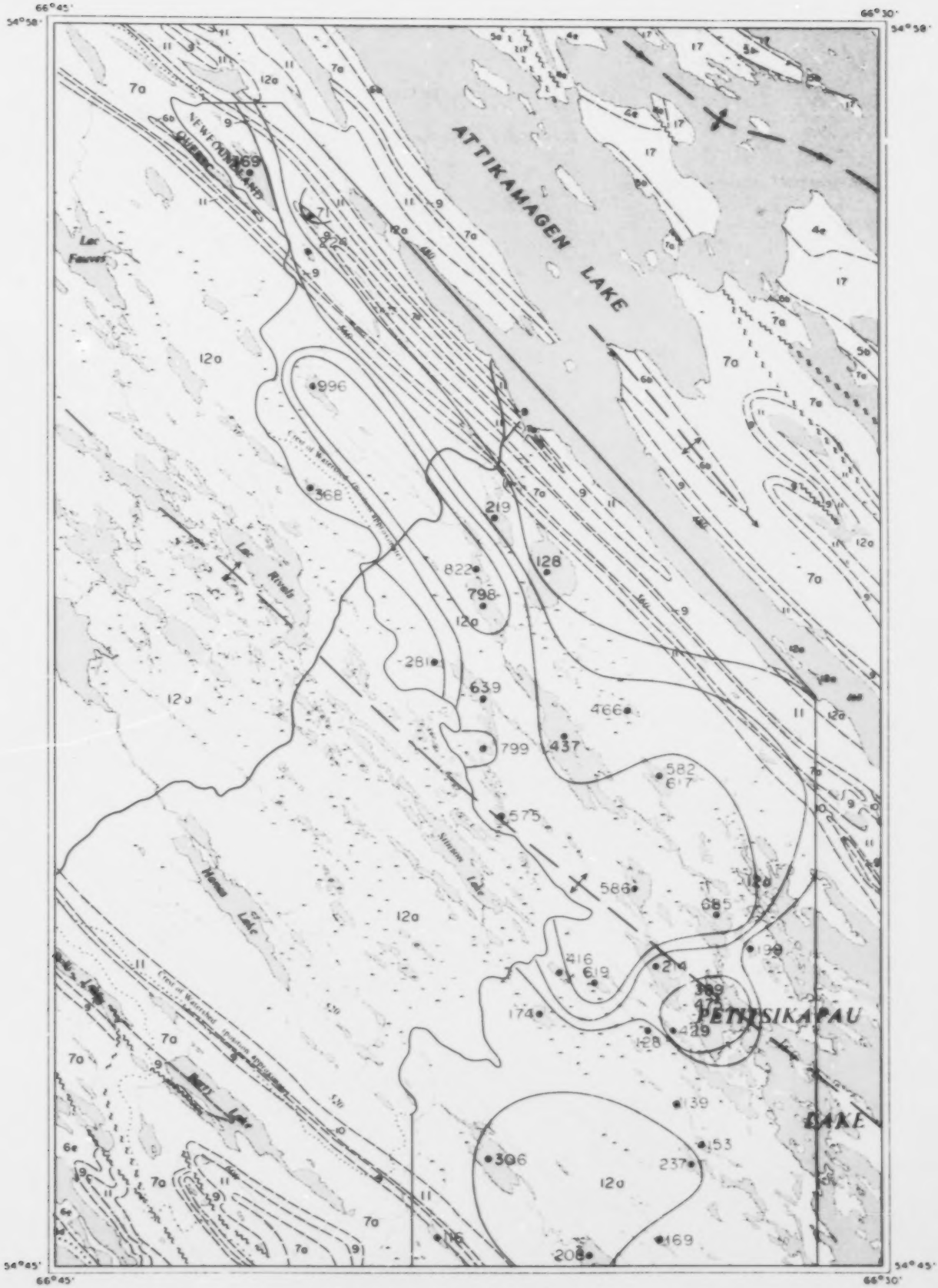

66°45'
66°30'
54°58'
54°45'
ATTIKAMAGEN LAKE
PETITSIKAPAU LAKE
Lac Fauves
Lac Rivards
Hunter Lake
Kilometres

Figure 4-10

LEGEND

Residual Zn in lake sediment. Anomaly 3

Geochemical Contours, Residual Zn

97%*	———	2.20 s.d.
92%	—— ——	1.70
85%	———	1.30
70%	———	0.55
40%	———	−0.40

*Percentiles based on total data from 9 follow-up areas.

• 1.72 Residual Zn in lake sediment, std. dev. units

Geologic boundary .....

Fault .....

Elevation in metres above sea level

Bedrock Geology: see Table 4–1 for key

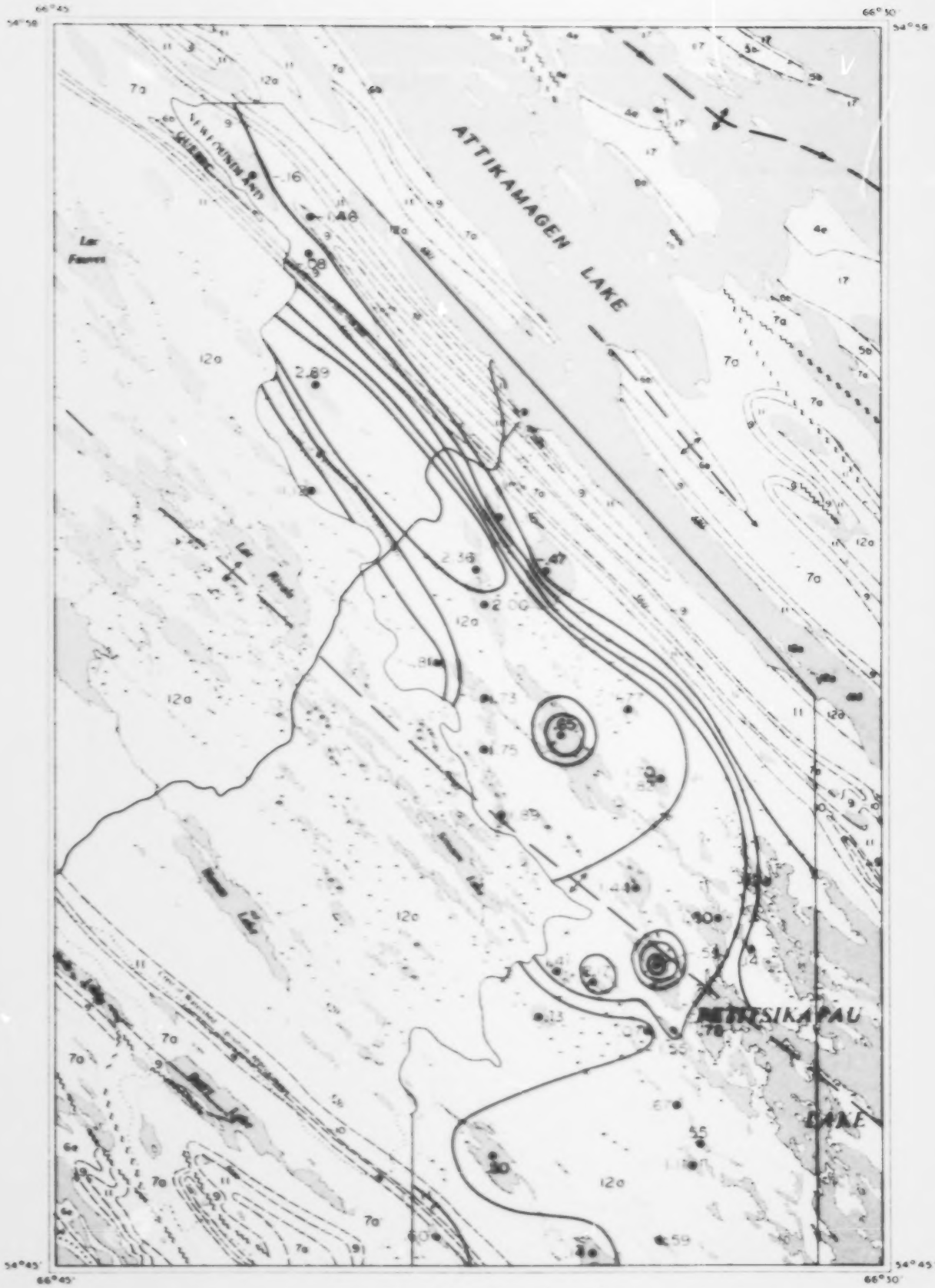

66°45'
66°30'
54°30'
54°45'
ATTIKAMAGEN LAKE
Les Fleurs
Les Rivets
MISSISKAPAU
LAKE
0 1 2 3 4 5
Kilometres

Figure 4-11

LEGEND

Zinc in lake water. Anomaly 3

Geochemical contours, Zn in water

97%*	~	21 µg/L
92%	~	12
85%	~	8
70%	~	6
40%	~	4

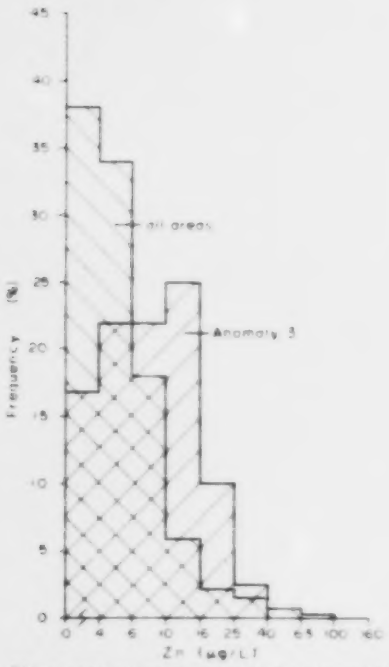
Geologic boundary .....

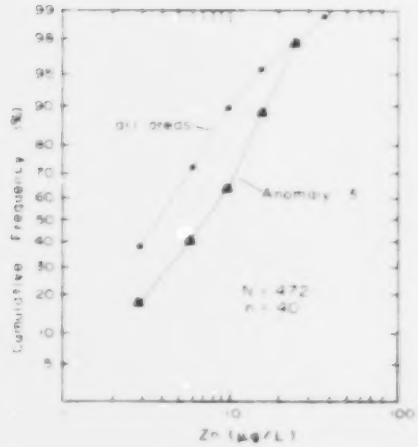
Fault .....

• Zinc in water, µg/L

Elevation in metres above sea level

Bedrock Geology: see Table 4–1 for key





*Percentiles based on total data from 9 follow-up areas.

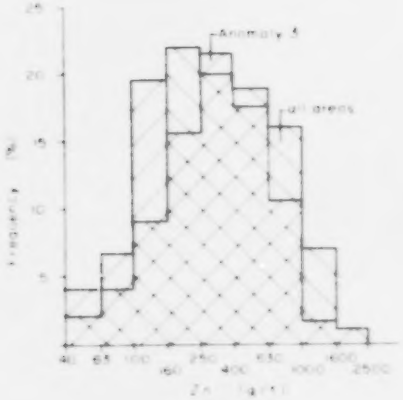
66°45'
54°58'
66°30'
54°38'
ATTIKAMAGEN LAKE
Lac Fauvel
54°45'
66°45'
66°30'
0 1 2 3 4 5
Kilometres

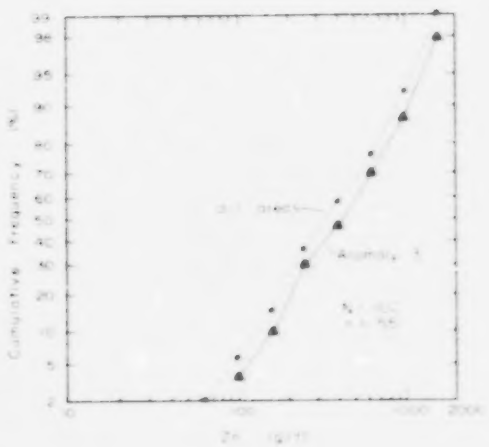
Figure 4-12

LEGEND

Zinc in stream sediment. Anomaly 3

Elevation in feet above sea level





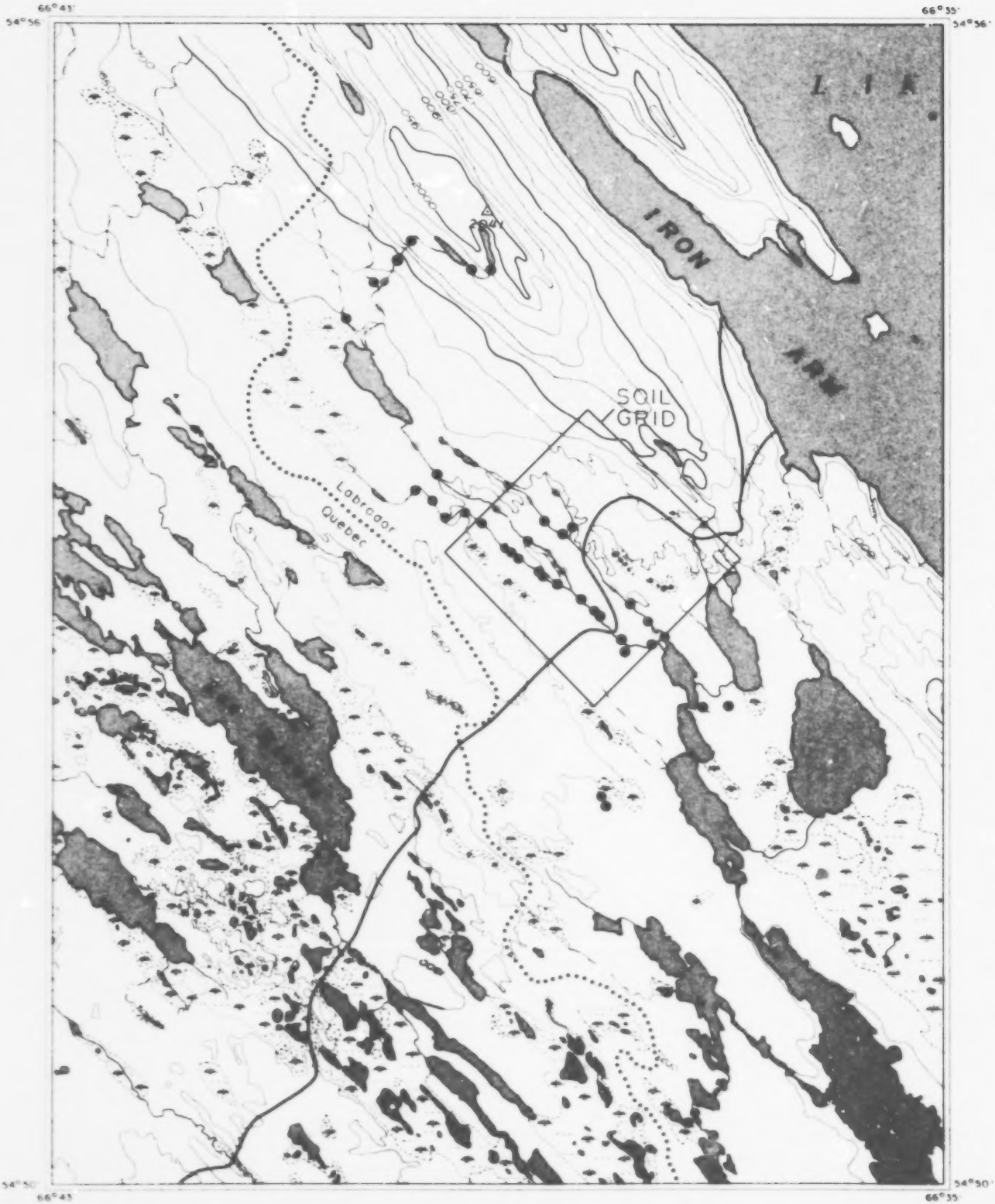
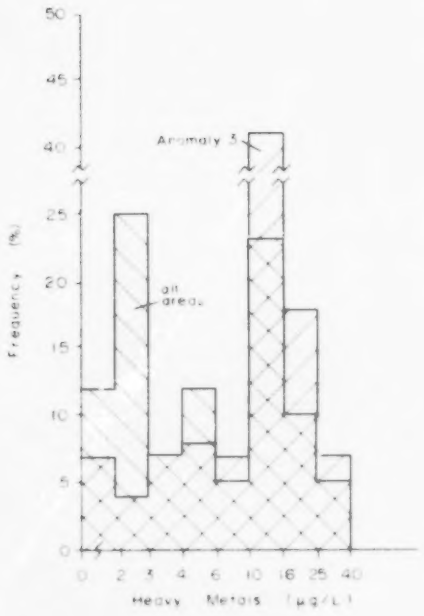

66°43'
66°35'
54°56'
54°56'
L I A
IRON
ARM
SOIL
GRID
Labrador
Quebec
54°50'
54°50'
66°43'
66°35'
0
1
2
3
Kilometres
230
540
780
1000
1300
Zn (g/t)
0
40
70
85
92
97
100
percentile

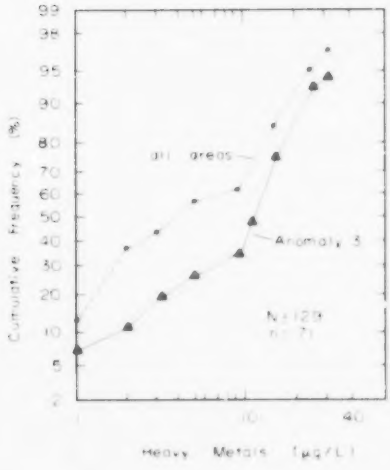
Figure 4.13

LEGEND

Heavy metals in stream water. Anomaly 3

Elevation in feet above sea level





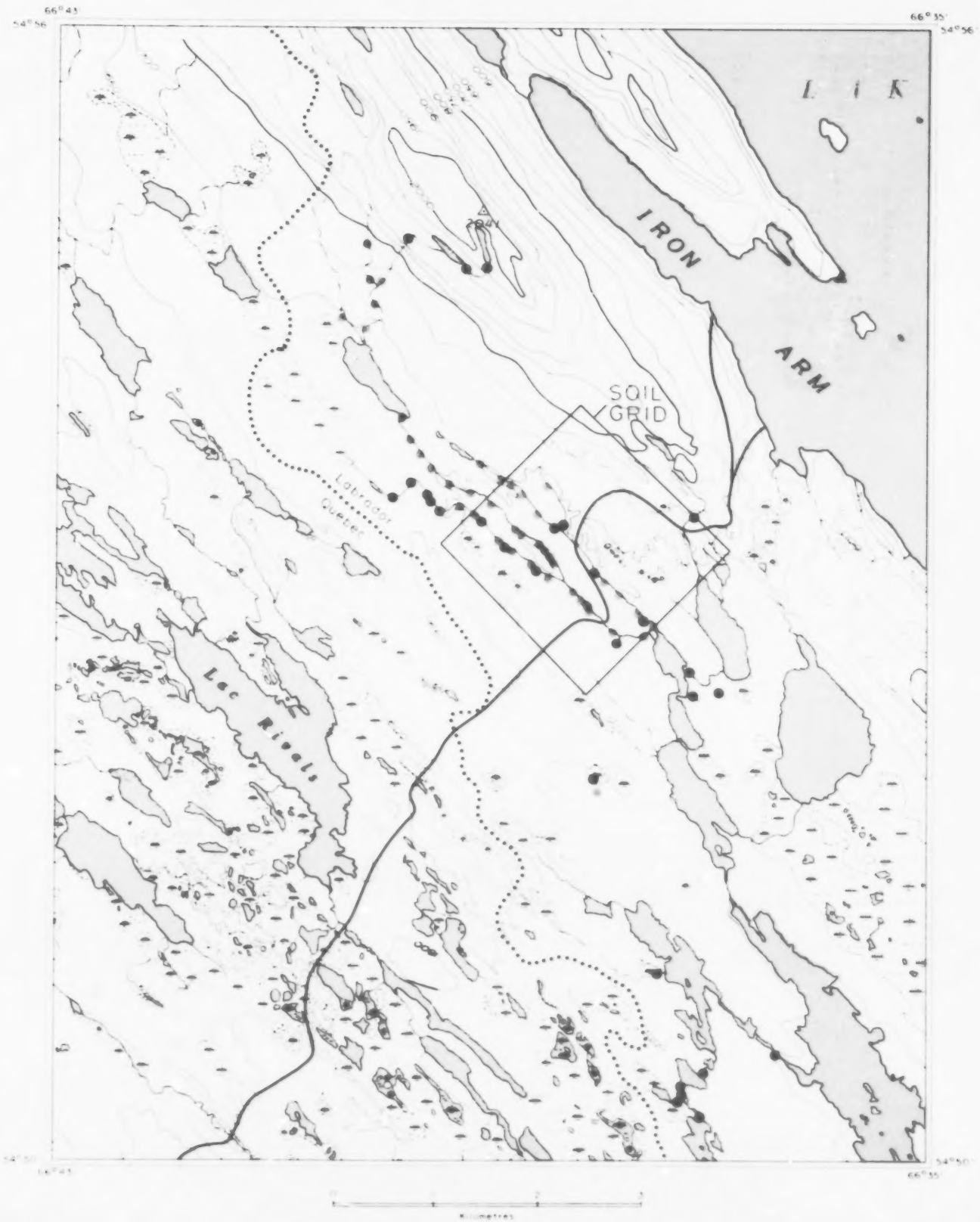

66°43'
54°56'
66°35'
54°56'
L I K
IRON
ARM
SOIL
GRID
Labrador
Current
Lac Rivals
54°50'
66°43'
66°35'
54°50'
kilometres
3
10
15
20
30
heavy metals (µg/L)
0
40
70
85
92
97
100
percentile

Figure 4.14

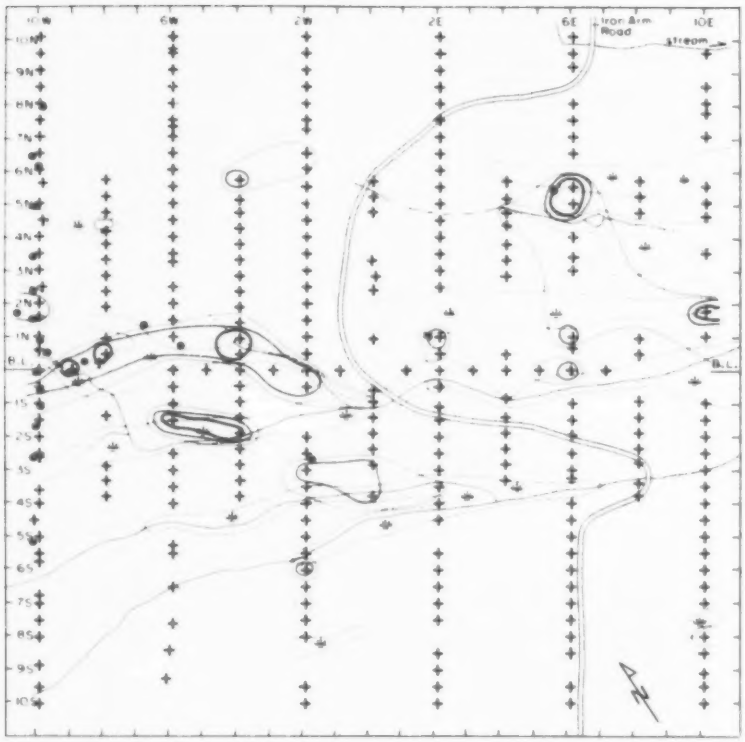


Figure 4-15

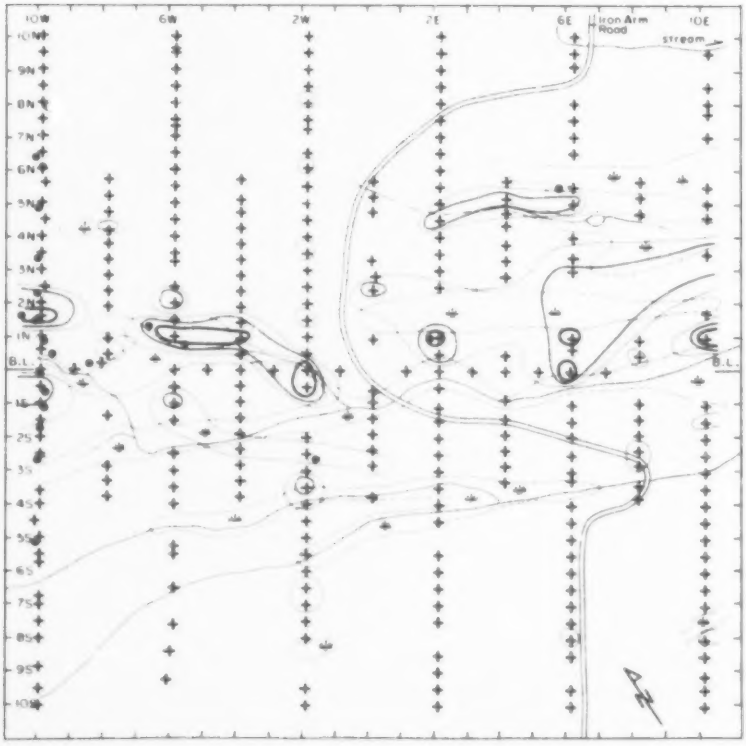


Figure 4-16

LEGEND

Contour Intervals:

Percentile	Zn (g/t)	Residual Zn (s.d.)
97	1000	2.25
92	330	1.40
85	210	1.00

soil sample site . . . . . +

bog . . . . . ⌒

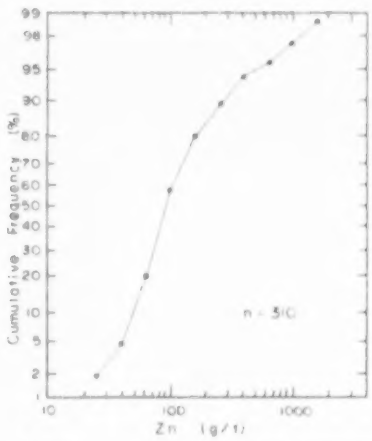
stream . . . . . ⌒

road . . . . . ⌒

rock sample site . . . . . •

0 500 1000

metres



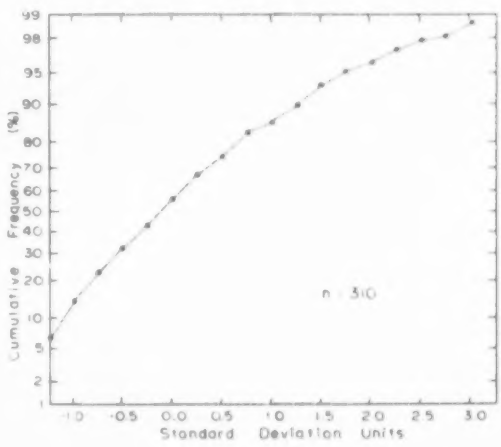


Figure 4-15: Zn in soil, Anomaly 3.

Figure 4-16: Residual Zn in soil, Anomaly 3.

LEGEND

Zinc in lake sediment. Anomaly 4

Geochemical Contours, Zn

97%*		780 g/t
92%		500
85%		350
70%		200
40%		110

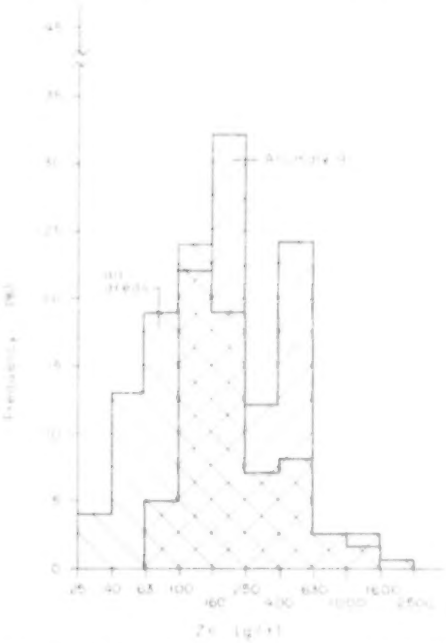
Geologic boundary .....

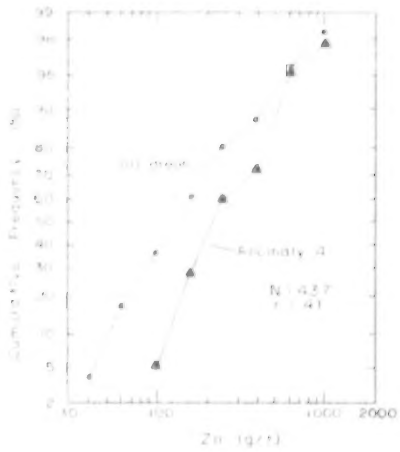
Fault .....

• 80 Zinc in lake sediment, grams/tonne

Elevation in metres above sea level

Bedrock Geology: see Table 4–1 for key





*Percentiles based on total data from 9 follow-up areas.

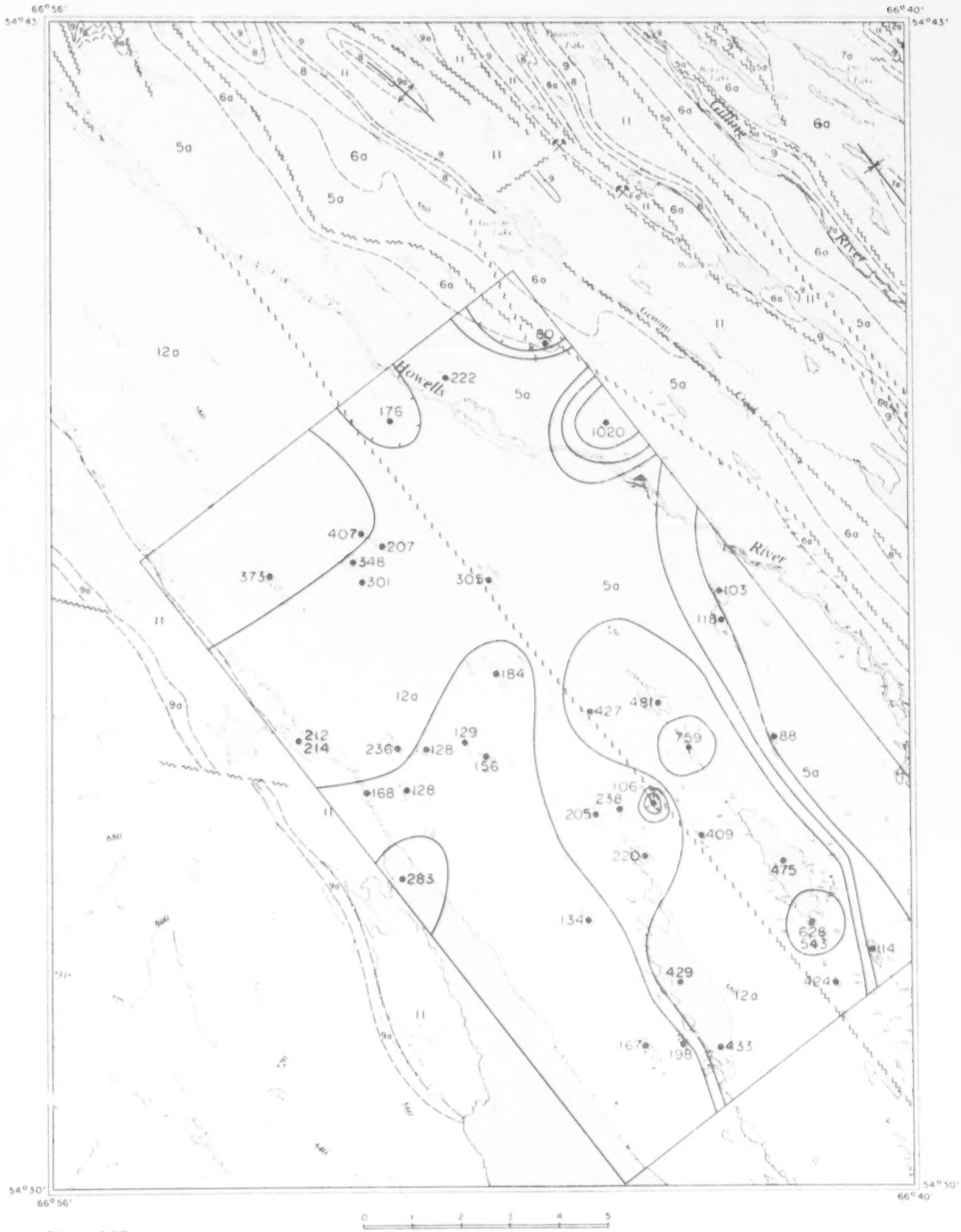

66°56'
54°43'
66°40'
54°43'
Howells
River
Gemini
Creek
Lake
54°30'
66°56'
54°30'
66°40'
0 1 2 3 4 5
Kilometres

Figure 4-17

LEGEND

Residual Zn in lake sediment, Anomaly 4

Geochemical Contours, Residual Zn

97%*	⌒	2.20 s.d.
92%	⌒	1.70
85%	⌒	1.30
70%	⌒	0.55
40%	⌒	−0.40

*Percentiles based on total data from 9 follow-up areas.

• 1.71 Residual Zn in lake sediment, std. dev. units

Geologic boundary . . . . .

Fault . . . . .

Elevation in metres above sea level

Bedrock Geology: see Table 4–1 for key

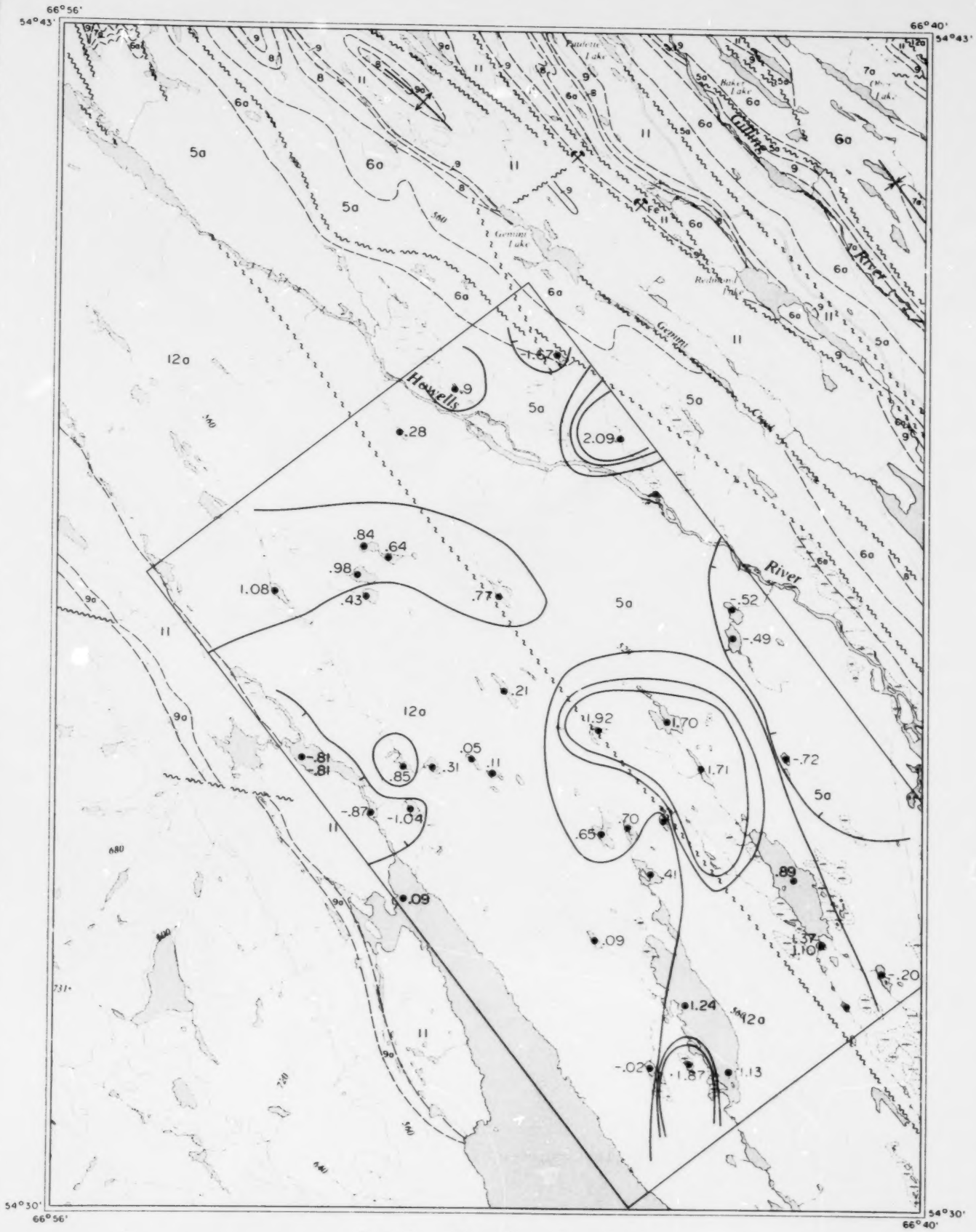

66°56'
54°43'
66°40'
54°43'
54°30'
66°56'
54°30'
66°40'
Gullhire
River
Howells
River
Geppini
Geppini Lake
Redmond Lake
Pattiette Lake
Hake Lake
5a
6a
11
12a
9a
7a
.9
.28
1.67
2.09
.84
.64
.98
1.08
.43
.77
.21
.05
.11
.31
.85
-.81
.81
-.87
-1.04
.09
.09
.65
.70
.41
1.92
1.70
1.71
-.72
-.52
-.49
.89
-.37
1.10
-.20
1.24
-.02
1.87
1.13
0 1 2 3 4 5
Kilometres

Figure 4-18

LEGEND

Zinc in lake water, Anomaly 4

Geochemical Contours, Zn in water

97%*	———	21 µg/L
92%	———	12
85%	———	8
70%	———	6
40%	———	4

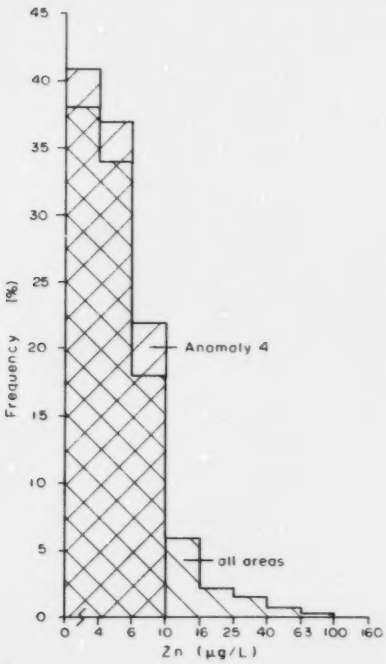
Geologic boundary . . . . . /——

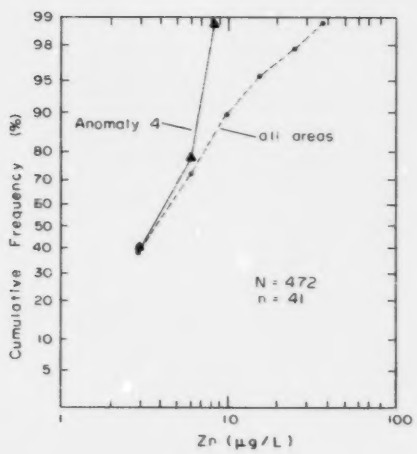
Fault . . . . . ~~~~~

• 8 Zinc in water, µg/L

Elevation in metres above sea level

Bedrock Geology: see Table 4–1 for key





*Percentiles based on total data from 9 follow-up areas.

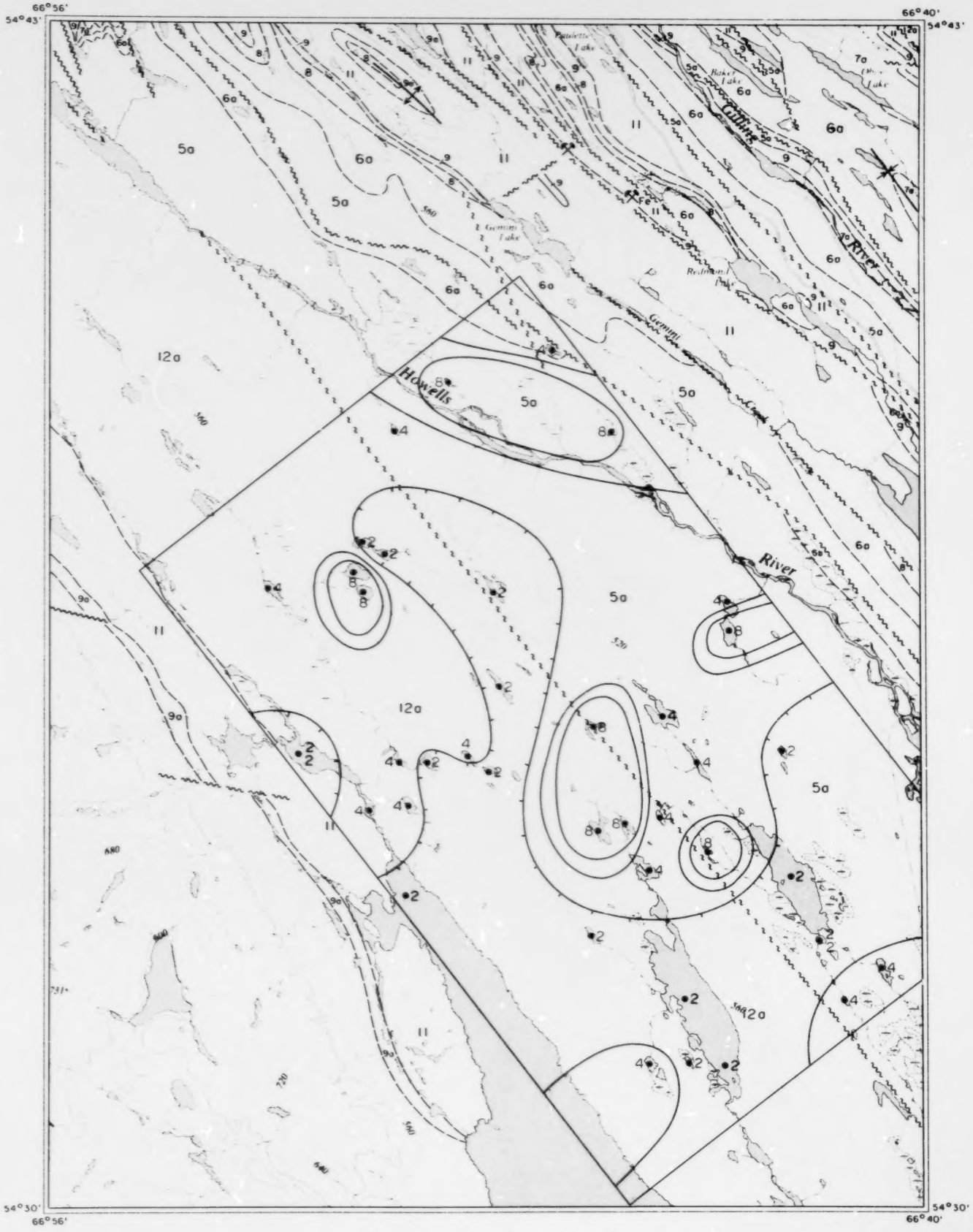

66°56'
54°43'
66°40'
54°43'
Howells
River
Gemini
Gemini Lake
Gilbert
Fe
54°30'
66°56'
66°40'
54°30'
0 1 2 3 4 5
Kilometres

Figure 4-19

LEGEND

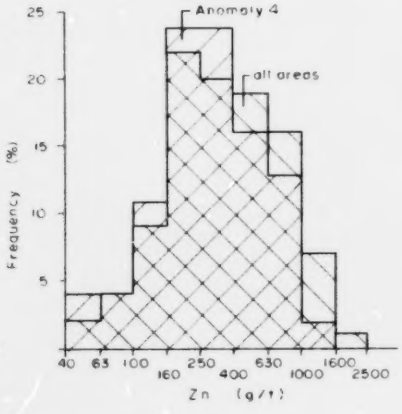
Zinc in stream sediment, Anomaly 4

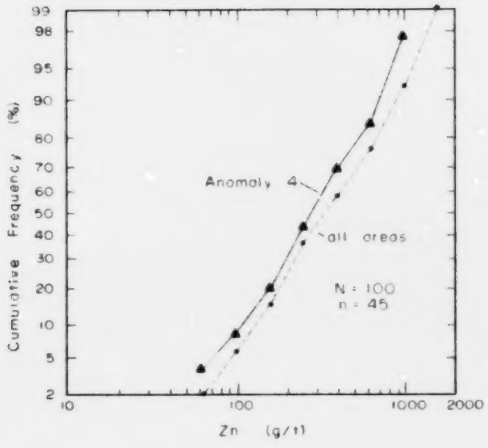
Geologic boundary . . . . . .

Fault . . . . . .

Elevation in metres above sea level

Bedrock Geology: see Table 4–1 for key





66°56'
66°40'
54°43'
54°30'
Howell
River
Caribou
12a
5a
6a
11
9
8
90
230
540
780
1000
1300
Zn (g/t)
0
40
70
85
92
97
100 percentile
0
1
2
3
4
5
kilometres

Figure 4-20

LEGEND

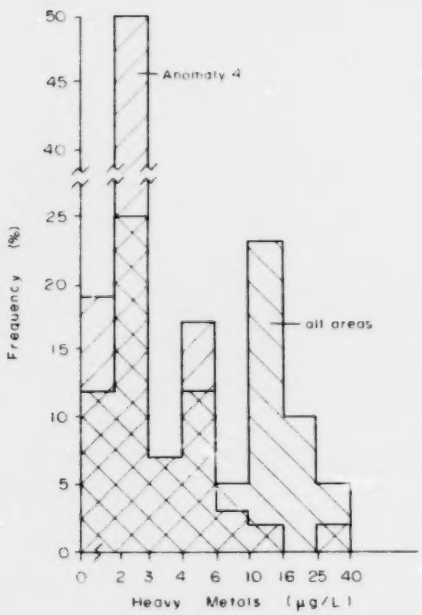
Heavy metals in stream water, Anomaly 4

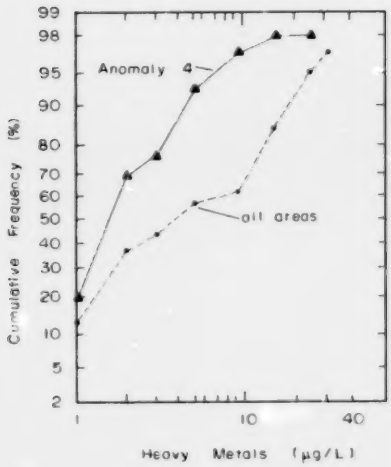
Geologic boundary . . . . . .

Fault . . . . . .

Elevation in metres above sea level

Bedrock Geology: see Table 4–1 for key





66°56'
54°43'
66°40'
54°43'
Howells
River
54°30'
66°56'
66°40'
54°30'
3
10
15
20
30
heavy metals (µg/L)
0
40
70
85
92
97
100
percentile
0
1
2
3
4
5
kilometres

Figure 4-21

CHAPTER 5

FOLLOW-UP SURVEYS OUTSIDE THE LABRADOR TROUGH

Introduction

The remaining anomalies, 5, 8 and 14, lack the common geologic setting of the Trough anomalies discussed previously. Anomaly 5 occurs in Archean rocks of the Superior Province, Anomaly 8 is underlain by Helikian peralkaline granite and felsic volcanics of the Nain Province, and Anomaly 14 is underlain by gneiss in the Churchill Province.

Anomaly 5

Geology and Mineralization

This area is found in the northwestern part of NTS map area 23G/15 and the western part of 23J/2. Geological mapping in this part of the Superior Province is very limited. The entire area is mapped as pyroxene granulite and unseparated felsic intrusives of the Archean Ashuanipi Complex. More detailed mapping in areas of the Ashuanipi Complex immediately north of Anomaly 5 suggests that the geology is actually more complex. Kidd (1950) identified orthogneiss, paragneiss and amphibolite, as well as intrusions of pegmatite, granite and diorite.

The only mineralization known from the area is Cu, found during a traverse around a lake where the sediment yielded 210 g/t Cu in the regional survey. Scattered gossan zones with spotty disseminated chalcopyrite were found in mafic intrusive rocks (McConnell, 1980). A sample of this mineralized rock analyzed 2170 g/t Cu. This single traverse is the only known ground follow-up done in this region.

Lake Sediment/Water Geochemistry

Follow-up lake sampling over the 230 km^2 area was done to investigate high Cu and Ni contents in reconnaissance sediment samples. Maximum values of 210 g/t Cu and 170 g/t Ni had been found. In general the follow-up data confirmed but failed to extend or intensify the anomaly. Summary geochemical statistics are found in Table 3-1.

The maximum Cu (179 g/t) and Ni (138 g/t) analyses in the follow-up data were lower than the maxima of the regional survey. The original high Cu lake (210 g/t) on resampling yielded 113 g/t. Nonetheless, Cu mineralization was located in the catchment basin of this lake as described above. The Ag content in this lake sediment was the highest found at Anomaly 5, 0.8 g/t compared to the anomaly mean of 0.25 g/t. Most analyses of heavy metals and Zn in lake waters in the southern half of the anomaly are at or below detection limits. Waters from the northern portion are moderately enriched, with several heavy metal analyses of 10 µg/L and maximum Zn values of 26, 18, 13 and several of 9 µg/L.

The variations in geochemical relief across the anomaly suggest that the bedrock geology is considerably more varied than existing geology maps indicate. The presence of minor, local chalcopyrite mineralization in the drainage basin of one lake with elevated Cu in sediment indicates both that lake sediment geochemistry is an effective prospecting technique in this area and that mineralizing processes have operated in this part of the Superior Province.

Anomaly 8

Geology and Mineralization

Anomaly 8 occupies approximately 290 km^2 in the southeastern third of NTS map area 13N/11. The geology of the area was mapped at 1:100,000 by Hill (1981), on whose work the accompanying map (Figure 5-1) is based. The oldest rocks are Archean tonalite gneisses deformed during the Kenoran Orogeny about 2500 Ma. Paleohelikian gabbroid and granitoid intrusives of the Nain igneous complex were emplaced about 1400 Ma. Following a period of uplift and erosion, the two-phase Flowers River Igneous Suite was emplaced. The older phase is a sequence of subaerial felsic volcanic rocks. These form a cap on the underlying younger phase, a batholith of peralkaline granite. Despite severe sodium depletion in the volcanics, Hill believes they were originally peralkaline on the basis of their trace element contents, and hence, probably related genetically to the underlying granite.

Thirteen mineral occurrences are known in the anomaly area. In order of decreasing abundance these include fluorite, pyrite, sphalerite, galena and chalcopyrite, and one analysis of peralkaline granite with anomalous levels of Zr, Nb and Y. Two of these are abnormally radioactive. Most are found in the volcanic rocks, three in the peralkaline granite and two in a monzonite of the Nain igneous complex.

Lake Sediment/Water Geochemistry

Reconnaissance sediment data from the Anomaly 8 area show marked enrichment in Zn, Mo, F and Pb. Maximum values are 2400, 210, 1050 and 365 g/t respectively. The

highest Zn and Pb contents are from the same lake and are considerably greater than the second highest samples which are 460 g/t Zn and 40 g/t Pb.

Follow-up lake sampling confirmed the reconnaissance scale anomaly. A broad area of high Zn values (>200 g/t) highlights the central part of the anomaly and is essentially confined to the volcanic terrain (Figure 5-1). This zone has two foci, an eastern one with a maximum of 560 g/t and a western one with a maximum of 2370 g/t. The dispersion pattern of Zn in water (Figure 5-2) is similar to that of Zn in sediment. The two foci of anomalous Zn in sediment correspond to the two highest areas of Zn in water. The western anomalous area, however, is extended and better defined in waters because water samples were obtained from four small ponds from which no sediment could be retrieved. One of these (70 μg/L) is the highest analysis from Anomaly 8 and is located about 0.5 km upstream from the lake with 2370 g/t Zn in sediment. It would seem, therefore, to be situated close to a source of the metal which has found its way into the larger lake.

An interesting pH anomaly is also located within a 2 km radius of the 2370 g/t Zn lake. Ten sample sites from five different drainage systems have pH values in lake waters ranging from 5.2 to 5.9. These are the only lakes analyzed in the Anomaly 8 area with a pH<6.0. The mean pH of all 61 lake sediment/water sites is 6.4. Although other explanations are possible, a likely cause for the abnormally acid water is the oxidation of sulfides.

Soil Geochemistry

In an attempt to determine more closely the source of the base metals, ground work was done in the area of the 2370 g/t Zn lake. Outcrop is scarce (<5%) and includes flow-banded rhyolite, some porphyritic rhyolite and brecciated and altered zones. Minor disseminated sulfides were encountered but nothing which would fully explain the magnitude of the anomaly. One sample of pyritiferous rhyolite analyzed 1800 g/t Zn and 436 g/t Pb. This outcrop and its strike extension, however, are slightly outside the catchment basin of the lake.

Glacial drift cover is estimated at 1 to 3 m. A grid (1 by 1.4 km) was laid out adjacent to the northwest shore of the lake and encompasses the pond with the 70 μg/L Zn in water. Samples of B horizon soils were collected from 104 sites along lines spaced 200 m apart. The resulting analytical data are disappointingly low, particularly in Zn (McConnell, 1981). The mean Zn content is 23 g/t and the maximum is 109 g/t. The higher values (>60 g/t) are confined to the western half of the grid but otherwise the Zn dispersion pattern is quite random. The elements Mo, Pb and Ag form more coherent patterns and, in almost all instances, the higher values, ($>\bar{x} + 2\sigma^-$), are confined to the southwest quadrant. Molybdenum has a mean of 3 g/t and a high value of 138 g/t in a sample from the most westerly line. Lead has a mean of 12 g/t and a maximum of 245 g/t, again in the southwest. All but 5 analyses of Ag are below the detection limit of 0.2 g/t but four of the five exceptions form a tight cluster in the southwest.

A VLF electromagnetic survey (EM-16) was conducted across the grid. No well defined conductor was recognized. As this type of survey is designed to respond to massive sulfides, the presence of disseminated sulfides would go undetected.

In conclusion, the ground follow-up at Anomaly 8 failed to account for the high levels of Zn in lake waters and Zn and Pb in lake sediment. This suggests that either the drift from which the soils are derived is not of local origin and does not reflect local bedrock geochemistry or the grid itself does not encompass mineralization. The most likely explanation is the former. A suboutcropping source of Zn could readily furnish a supply of the metal to groundwaters which ultimately would produce anomalous levels in lake waters and sediments. The upper levels of the till unit sampled would not reflect the underlying mineralization. The results here stress the importance of understanding the Quaternary history of an area in order to apply the most suitable exploration methods. A study of the till at Anomaly 8 might well suggest the need for deep overburden drilling or basal till sampling perhaps in conjunction with groundwater sampling.

Anomaly 14

Geology

The anomaly, located in the Churchill Province, encompasses about 100 km^2 of the northwestern portion of NTS map area 14D/10 and northeastern 14D/11. The only bedrock mapping in the area is reconnaissance work compiled by Taylor (1975) at a scale of 1:250,000. Taylor described the area as being underlain dominantly by granulite facies hypersthene-quartz-feldspar gneiss or biotite-hypersthene-quartz-feldspar gneiss. A small area is mapped as mylonitized garnet-quartz-feldspar gneiss. The rocks were strongly deformed and metamorphosed during the Hudsonian Orogeny but the age of the original rocks is uncertain; they are tentatively assigned to the Aphebian. Aeromagnetic contour maps at 1:50,000 scale were recently published for this area (G.S.C., 1982a,b).

Lake Sediment/Water Geochemistry

The area was selected for detailed lake sampling to investigate a portion of a larger northwest trending zone which transects NTS map area 14D. The zone is defined by abnormally high levels of Cu, Ni, Zn and Co in the reconnaissance lake sediment data. Detailed sampling confirmed and intensified the reconnaissance anomaly. Of the nine follow-up areas, Anomaly 14 has the highest mean content in lake sediment of the elements Cu (73 g/t), Co (20 g/t) and

Ni (59 g/t). It also has the greatest mean lake depth (6.5 m) and the second highest mean Fe content (2.94%). Both depth and Fe content are known to correlate positively with the content of many trace elements in sediment; hence the intensity of the anomaly relative to other follow-up areas may be partly attributable to the greater than average depths and higher than average Fe concentrations. If the mean Cu and Ni contents are evaluated in terms of the regression equations derived from the reconnaissance data (see Chapter 2), the residual values are still very high. The mean residual values of Cu and Ni are in excess of three standard deviation units about the mean residual values.

Significant, nearly coincident anomalies of Cu and Ni are located in the northern portion of the area (Figures 5-3 and 5-4). Within this zone are found lake sediments which have Cu contents of 132, 188 and 203 g/t, and Ni contents of 143, 154, 180 and 311 g/t. The 311 g/t Ni analysis is higher than any encountered in the samples from the 8048 lake sites of the original reconnaissance survey. The lake from which this sample was obtained is situated on the flank of a south-southeast trending aeromagnetic ridge (G.S.C., 1982b). Several gossan zones were seen from the air during the follow-up lake sampling survey. Six grab samples of severely weathered gossans adjacent to two of the most anomalous lakes consist of quartz-garnet-feldspar ± graphite paragneiss. The two graphitic samples are considerably enriched in Cu, Ni and Co relative to the four nongraphitic but otherwise similar appearing rocks. The graphitic rocks have the following analysis (g/t): Cu (213 and 376); Ni (118 and 109); and Co (36 and 31). By contrast, the means (g/t) of the other four samples are: Cu (40); Ni (6); and Co (3).

The magnitude of geochemical relief and the presence of distinctive geochemical dispersion patterns indicate that the area is underlain by lithologies of strongly contrasting compositions, possibly containing Cu and/or Ni mineralization.

Figures 5-1 through 5-4.

LEGEND

Zinc in lake sediment, Anomaly 8

Geochemical Contours, Zn

97%*	~	780 g/t
92%	~	500
85%	~	350
70%	~	200
40%	~	110

Geologic boundary . . . . . ~

Dike or sill . . . . . ▱

Volcanic and intrusive breccia . . . . . ▼

Mineral occurrence . . . . . ✖

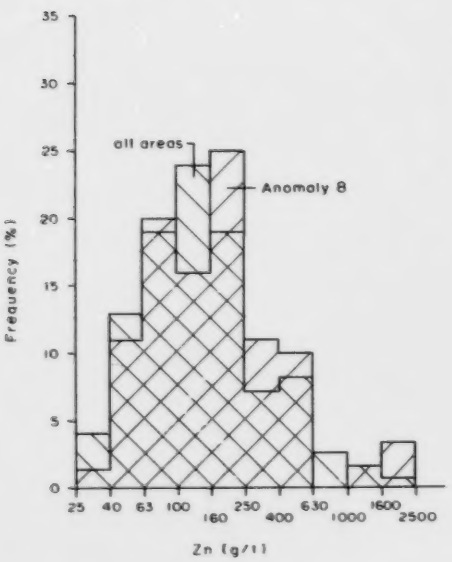
f = fluorite, gn = galena, py = pyrite,

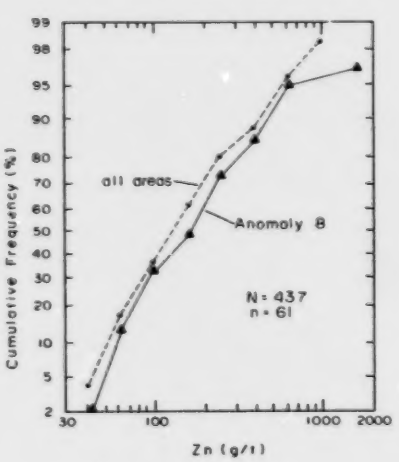
cp = chalcopyrite, sp = sphalerite

ra = total count scintillometer anomaly

•270 Zinc in lake sediment, grams/tonne

Elevation in metres above sea level





BEDROCK GEOLOGY

PROTEROZOIC

Neohelikian (or younger) - Flowers River Igneous Suite

Massive, leucocratic, peralkaline granite

Felsic volcanic rocks, may be intrusive in part
- **p** = massive quartz and quartz-feldspar porphyry
- **t** = crystal and lithic tuff
- **f** = massive and flow-banded felsite
- **b** = volcanic breccia and agglomerate

Paleohelikian - Nain Igneous Complex

Various rusty weathering, quartz-poor, granitoid intrusive rocks

Gabbroid plutons

ARCHEAN - Nain Structural Province

Banded feldspar-quartz-pyroxene-biotite gneiss

*Percentiles based on total data from 9 follow-up areas.

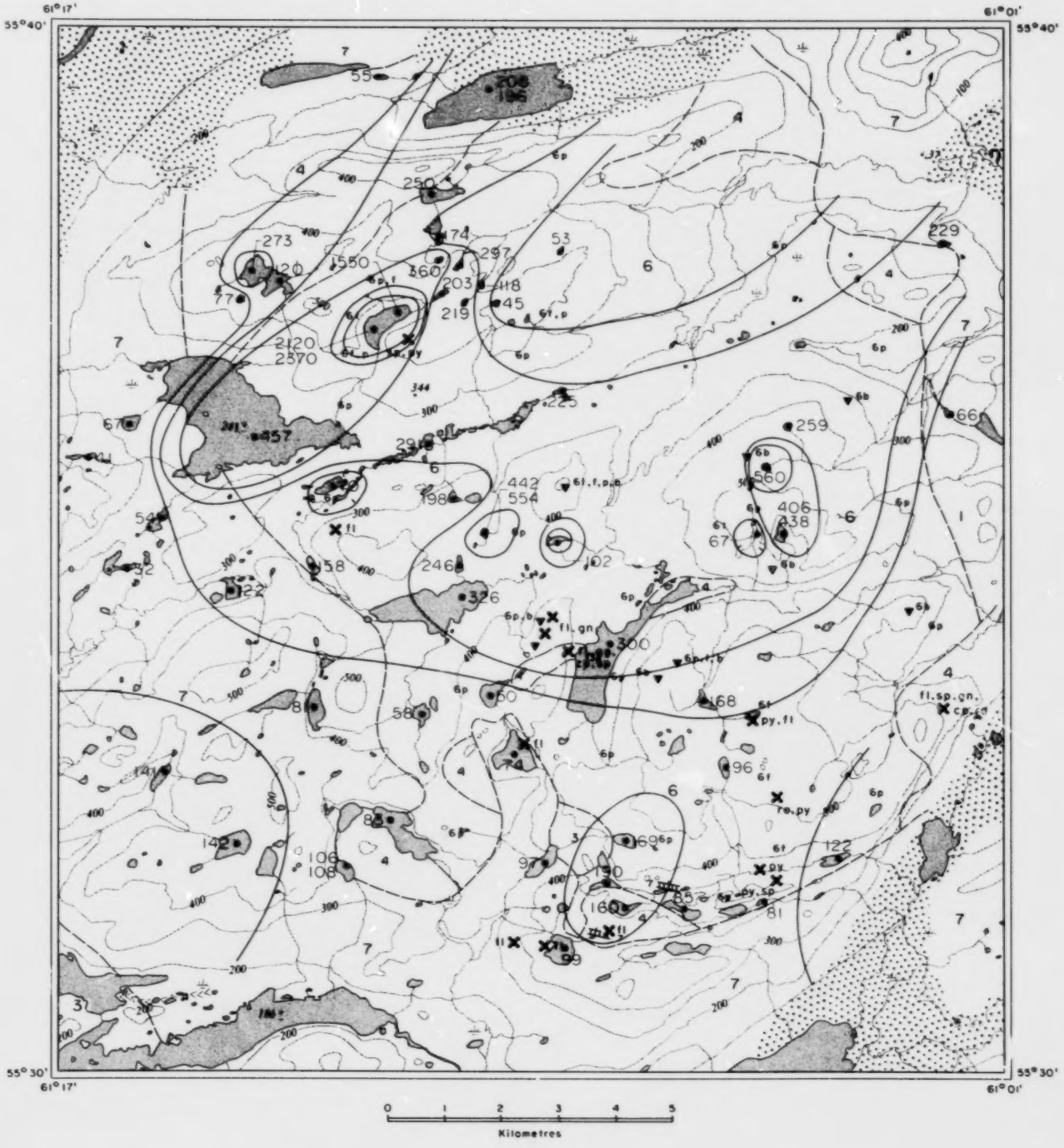


Figure 5-1

LEGEND

Zinc in lake water, Anomaly 8

Geochemical Contours, Zn in water

97%*		21 µ g/L
92%		12
85%		8
70%		6
40%		4

• 27 Zinc in lake water, µ g/L

Elevation in metres above sea level

Geologic boundary . . . . . /

Dike or sill . . . . . ▭

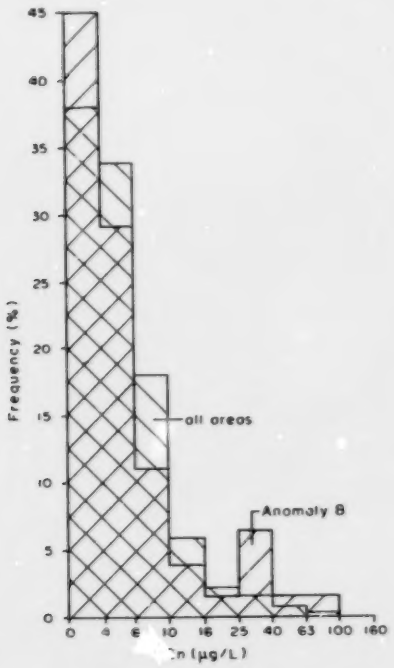
Volcanic and intrusive breccia . . . . . ▼

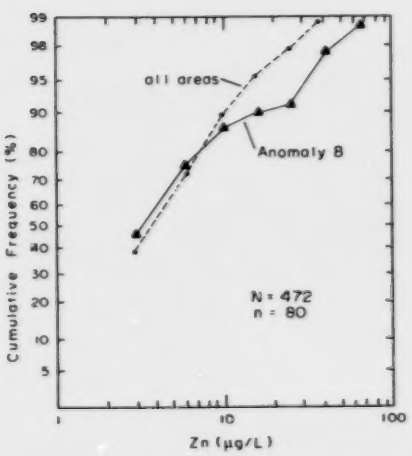
Mineral occurrence . . . . . ✖

f = fluorite, gn = galena, py = pyrite,

cp = chalcopyrite, sp = sphalerite

ra = total count scintillometer anomaly





BEDROCK GEOLOGY

PROTEROZOIC

Neohelikian (or younger) - Flowers River Igneous Suite

Massive, leucocratic, peralkaline granite

Felsic volcanic rocks, may be intrusive in part
- **p** = massive quartz and quartz-feldspar porphyry
- **t** = crystal and lithic tuff
- **f** = massive and flow-banded felsite
- **b** = volcanic breccia and agglomerate

Paleohelikian - Nain Igneous Complex

Various rusty weathering, quartz-poor, granitoid intrusive rocks

Gabbroid plutons

ARCHEAN - Nain Structural Province

Banded feldspar-quartz-pyroxene-biotite gneiss

*Percentiles based on total data from 9 follow-up areas.

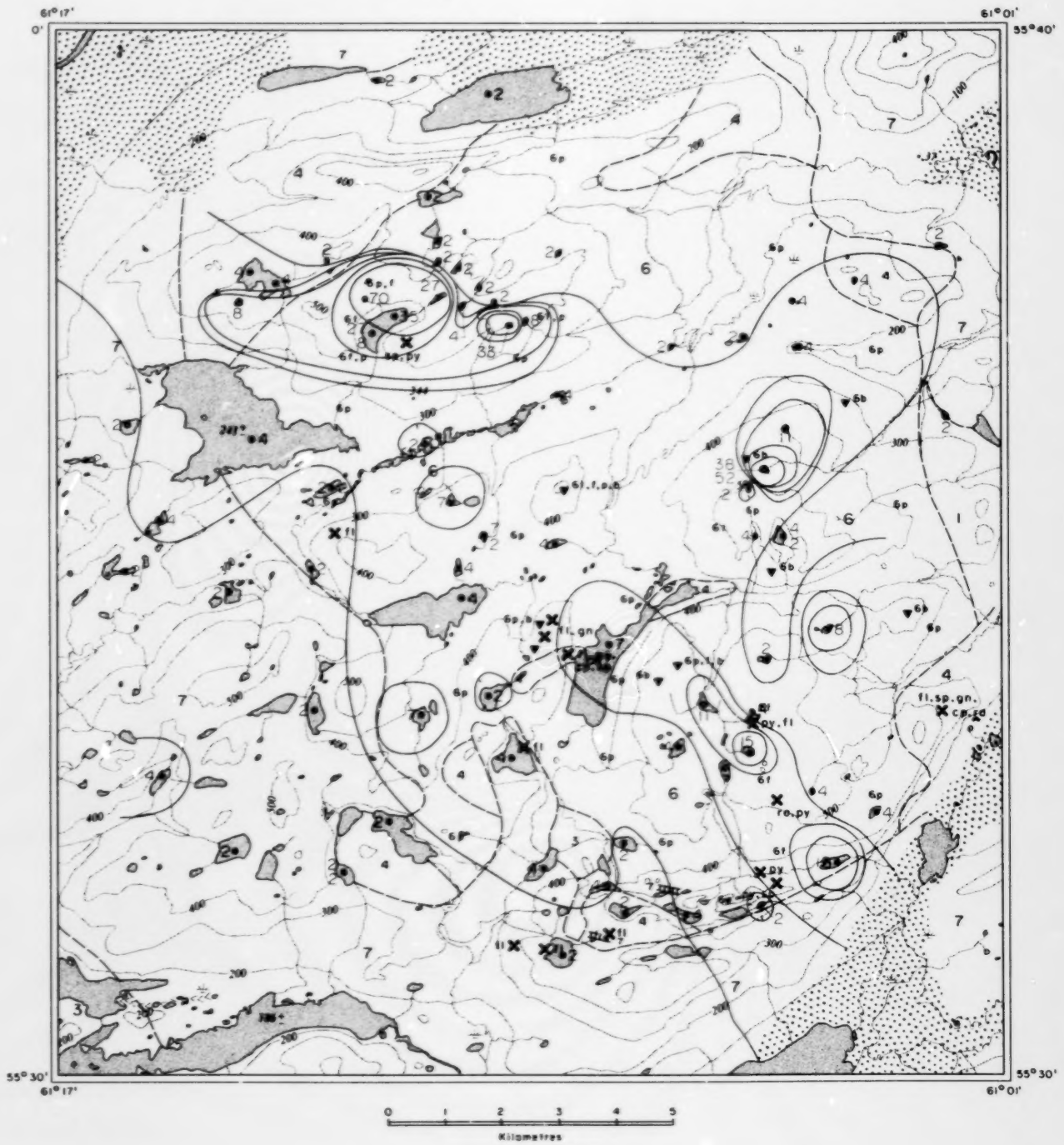


Figure 5-2

LEGEND

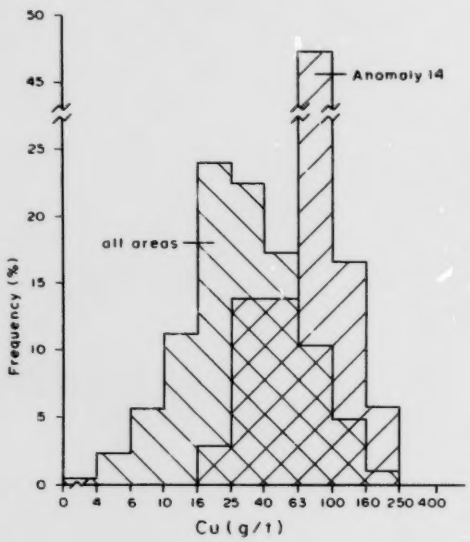
Copper in lake sediment, Anomaly 14

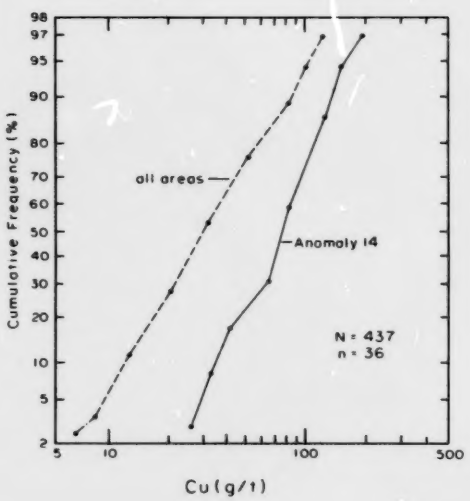
Geochemical Contours, Cu

97%*	~	125 g/t
92%	~	90
85%	~	67
70%	~	44
40%	~	25

•132 Cu in lake sediment, grams/tonne

Elevation in feet above sea level





*Percentiles based on total data from 9 follow-up areas.

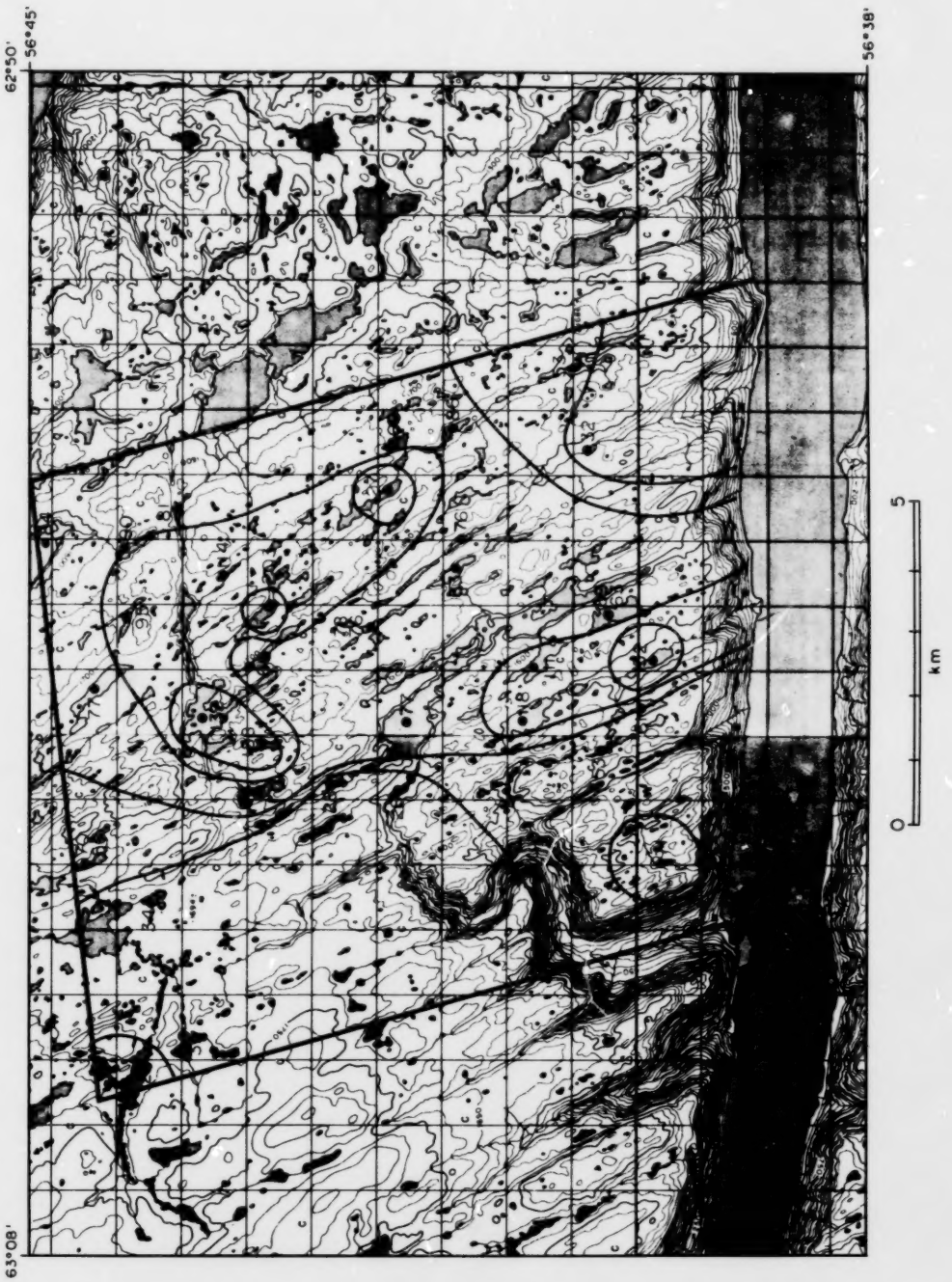


Figure 5-3

LEGEND

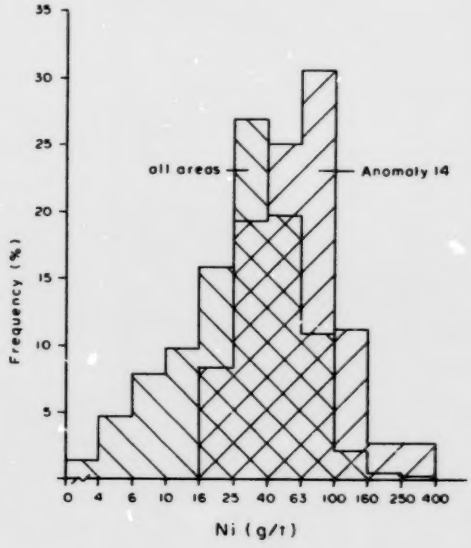
Nickel in lake sediment, Anomaly 14

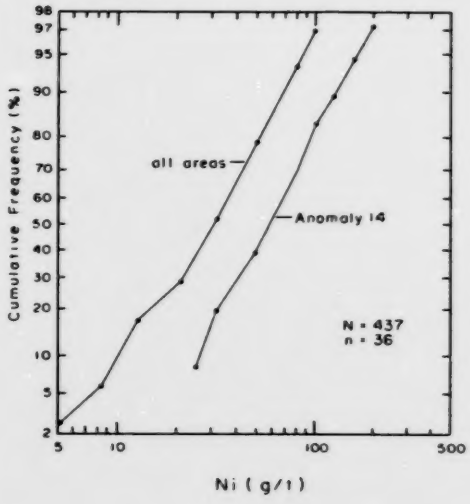
Geochemical Contours, Ni

97%*	100 g/t
92%	74
85%	59
70%	43
40%	25

•154 Ni in lake sediment, grams/tonne

Elevation in feet above sea level





*Percentiles based on total data from 9 follow-up areas.

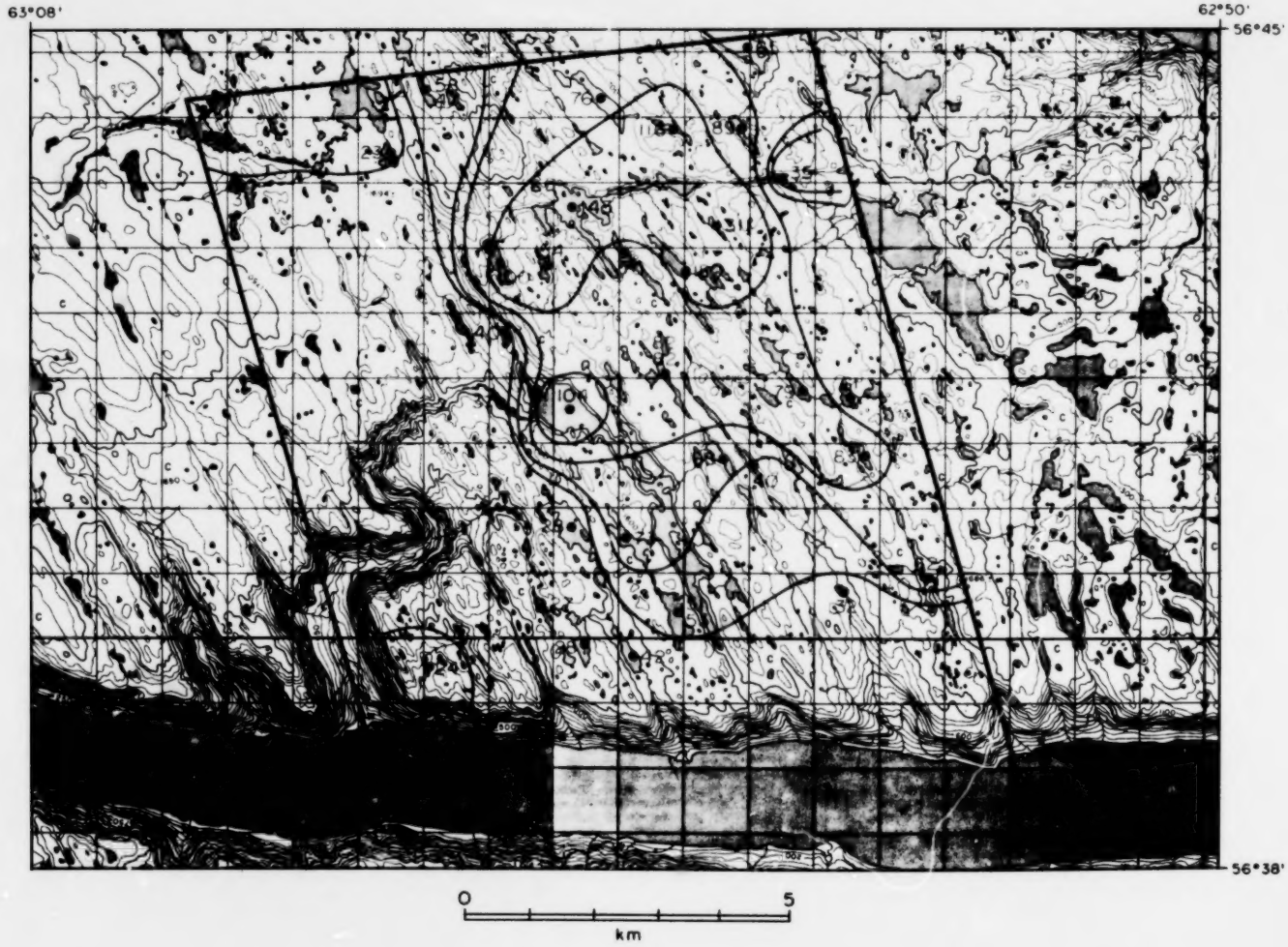


Figure 5-4

CHAPTER 6

CONCLUSIONS

Reconnaissance Survey

The ability of lake sediment and lake water geochemistry to reflect bedrock composition at a reconnaissance scale (1 sample per 17 km^2) has been demonstrated for areas of Labrador known to be enriched in base metals. By inference, high metal values in sediment and waters from less explored ares also indicate enrichment of metals in bedrock. A method of data consolidation, whereby analyses of individual samples are aggregated into one "composite sample" per 100 km^2, provides a reduced and more manageable data set. Such data smooth local geochemical "noise" and enhance regional features, while permitting multivariate statistical analyses to examine and compensate for inter-element correlations.

Some environmental factors which strongly influence the trace element content of lake sediment have been identified, particularly lake depth, Fe content and, to a lesser extent, organic content (LOI). In some areas these can combine to the point where a very poor correlation exists between bedrock composition and the geochemistry of lake sediments. These effects can be partly removed by the application of linear regression analysis to the data. Likewise, the acidity of water in a lake and its tributaries is important in governing the level of trace elements in the sediment. The correlation coefficient between Zn and pH is 0.52, indicating that sediments from more alkaline lakes are enriched relative to more acid lakes. This correlation, however, is based on pH determinations of surface water, and might be stronger if pH determinations were made on the water within the sediment itself.

Dispersion patterns, as defined by metal contents of sediment and residual metal content, reflect large scale geologic features including distinct zones of metal enrichment. In areas where detailed geologic mapping and base metal exploration has been done, these patterns can in most cases be correlated closely with distinctive lithologic groups or areas of mineralization. Examples include:

1) The enrichment of Cu, Pb, Zn and Ni in lake sediments from the northern surveyed portion of the Labrador Trough. Many base metal prospects are known from this area.

2) The enrichment of Mo, Pb and Zn in areas of volcanic and sedimentary rocks in the Central Mineral Belt (southern Nain Province) corresponding to several base metal occurrences.

3) The recently identified peralkaline granitic and volcanic terrain in central Nain Province with associated base metal and fluorite occurrences. This can be clearly distinguished from other granites in the area by the distinctive lake sediment geochemistry of Pb, Mo and Zn. Distinctive U, F, Zn and Pb geochemistry in the reconnaissance data has led to the discovery of a peralkaline granite in the Strange Lake area in Churchill Province. This intrusion is host to a promising deposit of Zr, Nb, Y, Be and rare earth elements.

In areas of less detailed mapping and exploration, several unexplored geochemical anomalies await ground investigation. These include:

1) Apparent zoning in the Mistastin Batholith, high Mo (and U) in the northwest and high Mo-F in the south.

2) A large area within the gneiss and mylonite terrain of the northern part of the Churchill Province. High levels of Cu, Pb, Ni and Co are characteristic, suggesting the rocks are metamorphosed supracrustal rocks with enhanced mineral potential.

3) Anomalous concentrations of Cu in scattered areas of the poorly understood paragneiss terrain north and west of Lake Melville in the Grenville Province.

4) Several areas of the Superior Province with high Cu and Ni concentrations in lake sediment.

Follow-up Surveys

Lake Sediment/Water Surveys

Lake sampling at the detailed scale confirmed all the regional anomalies and successfully identified areas within which subsequent stream and soil surveys yielded anomalous values of base metals and, in some cases, mineralization. As at the regional scale, interpretation of lake sediment and water data is improved by considering environmental factors such as Fe content, lake depth and pH. The first two factors form linear relationships with most base metals in sediment and their effects can be largely removed by the application of linear regression analysis. Water acidity and metal content, on the other hand, have a curvilinear relationship in most instances. For example, the mean Zn values in sediment samples from the Labrador Trough increase steadily from 70 g/t in lakes with a pH of 5.2 to a maximum of 220 g/t in lakes with a pH of 6.8 and then decline to 110 g/t in lakes with a pH of 7.8.

In the same data set, the heavy metal content of lake water decreases from a maximum of 5.5 μg/L in the most acid lakes (pH of 5.2) to 2.1 μg/L in the moderately alkaline

group of lakes and then increases to 4.3 µg/L in the most alkaline lakes (pH of 7.8). Consequently, depending on the acidity of the drainage systems in an area, dispersion patterns in lake sediments and those in lake waters may differ greatly. Ideally, both sample media should be analyzed in order to establish better priorities for further follow-up.

Stream Sediment/Water Surveys

Stream sediment and water surveys conducted in areas of anomalous base metal values in lake sediments also yielded anomalous values. In particular, stream water proved to be a very effective medium for delineating anomalies. Water samples have several advantages over sediments such as ease of collection, availability, homogeneity, and suitability for rapid field analyses. Collection of stream sediments sometimes proved difficult or impossible. Sediment sampling, however, does offer the advantage of permitting a much wider range of elements to be determined.

Soil Surveys

Samples of B horizon soils were collected from Anomalies 3 and 8 with mixed results. At Anomaly 3, soil sampling across a stream sediment/water anomaly yielded high Zn values (maximum 8000 g/t). Zn correlated strongly with Mn and LOI, and linear regression analysis was employed to produce residual Zn values. Dispersion patterns of the two types of Zn data are quite different. The highest raw Zn values appear to correlate with deposits of Fe and Mn oxides whereas some of the strongest residual Zn values correlate with high Zn values in nearby frost-heaved slate. Clearly there has been hydromorphic redistribution of Zn within the till but the ultimate source remains unknown. A possible explanation of the anomaly is the englacial transport of material from a source up-ice to the northwest.

Results of soil sampling at Anomaly 8 were disappointingly low. Only a hint of a soil anomaly was found, and only in contradistinction to the very low values elsewhere on the grid. No attempt was made to assess the nature of the till in this area; the results stress the need for such an understanding as well as a knowledge of local background levels before a proper interpretation of the soil data can be made.

Concluding Statement

These studies have been limited in scope to initial reconnaissance and preliminary follow-up stages of mineral exploration. As such they have demonstrated that conventional geochemical exploration methods, properly and systematically applied, are effective in Labrador and support earlier more limited results such as those of Brummer (1960). There remain, however, problems at the final stages of exploration, i.e. in defining the exact location, nature and extent of mineralization. At this stage conventional geochemical techniques such as soil and till sampling must be combined with surficial geological studies to determine the nature and provenance of the sampled material, and with geophysical methods to define drill targets.

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APPENDIX A

SAMPLE PREPARATION AND ANALYTICAL METHODS

Sample Preparation

Lake Sediment

Samples were sheltered from rain and partially dried out-of-doors in the field and further air-dried in the laboratory. For samples from the follow-up surveys, the process was hastened by drying them in low temperature (40°C) ovens. Samples were then crushed by beating the bags and their contents with a hammer. Those from the reconnaissance survey were then ball-milled whereas follow-up samples were disaggregated using a ceramic mortar and pestle.

The final step in the preparation consisted of sieving the samples and retaining the < 180 µm fraction for analysis.

Soil, Till and Stream Sediment

Samples were field-dried and sieved using stainless steel sieves. The < 180 µm fraction was retained for analysis.

Rock

Samples were crushed in a steel-plated jaw crusher and passed through a riffle splitter; representative splits were pulverized in a tungsten-carbide shatterbox.

Water

No special treatment was accorded samples prior to analysis.

Analytical Methods

As a check on sampling and analytical precision, one sample in a block of twenty was a site duplicate and another was a duplicate split of a normal sample. In addition, for lake sediment, stream sediment, soil, till and rock samples there was a control reference sample analyzed in each block of 20 samples. The analytical methods applied to the various sample media summarized below are taken from Wagenbauer et al. (1983) and G.S.C. Open File 509 (1978).

Element(s)	*Methodology*
Lake Sediment	
Cu, Pb, Zn, Ni, Co, Ag, Mn and Fe	React 1 g sample with 6 mL of a mixture of 4 M HCl and 1 M HNO_3 in a test tube overnight at room temperature. After digestion, immerse in a water bath at room temperature. Bring temperature up to 90°C and hold for 2 hours. Shake periodically. After cooling, dilute sample solution to 20 mL with de-ionized water and mix. Determine element concentrations with an atomic absorption spectrophotometer using an air-acetylene flame. Make background corrections for Pb, Ni, Co and Ag using a deuterium lamp.
Mo	React 0.5 g sample with 1.5 mL concentrated HNO_3 at 90°C for 30 minutes. Add 0.5 mL concentrated HCl and continue digestion for an additional 90 minutes at the same temperature. Cool and add 8 mL of 1250 mg/L Al^{3+} solution. Dilute solution to 10 mL and aspirate in a nitrous oxide—acetylene flame in an atomic absorption spectrophotometer.
F	Produce a sinter by fusing 250 mg of sample with 1 g of flux in a nickel crucible over a Fisher burner for 10 minutes. The flux consists of Na_2CO_3 and KNO_3 in a ratio of 2:1 by weight. Dissolve the residue with de-ionized water. Add 10 mL of 10% citric acid solution and 1 mL of 10 mg/L fluoride solution. Bring the resultant solution up to 100 mL with de-ionized water. Measure the fluoride content of the test solution using a fluoride ion electrode. Standard solutions contain sodium carbonate and citric acid in the same quantities as the sample solution.

Loss-on-ignition	Thoroughly dry sample at 100°C in a muffle furnace. Weigh 500 g of dried sample into a pre-weighed 30 mL beaker. Place in a cold muffle furnace and over a 2 to 3 hour period bring temperature up to 500°C. Leave sample there for an additional 4 hours to ensure thorough combustion of organic matter. Cool to room temperature and weigh. Express LOI as a percentage by calculating the percentage weight loss.

Stream Sediment, Soil and Till

Cu, Pb, Zn, Co, Ni, Mn, and Fe	Use the same method as employed for analyzing lake sediment except for the digestion which is as follows. Add 3 mL concentrated HNO_3 to 1 g of sample and let stand overnight. Place test tube in water bath at 90°C for 30 minutes and then add 1 mL concentrated HCl. Continue hot water bath for an additional 90 minutes. Then treat as described for lake sediment.
Ag	A different digestion method is employed than the above because it has been determined that the HCl in the stream sediment digestion may cause a significant portion of the Ag to precipitate as a chloride (Wagenbauer et al., 1983). The following digestion is used. Add 2 mL concentrated HNO_3 to 0.5 g of sample in a 10 mL test tube. Digest overnight at room temperature and then immerse for 2 hours in a 90°C water bath. When cool, dilute the solution to 10 mL with de-ionized water and analyze as described above.
Mo, F, LOI	Use same methods as described for lake sediment.

Rock

Mn and Fe	Fuse 0.1 g of sample in a 9 mL graphite crucible with 0.5 g of lithium metaborate at 1000°C. Pour the hot melt into a 250 mL polycarbonate bottle containing 25 mL of 4 vol % HCl and 5 mL concentrate. Digest at 90°C for 90 minutes. Cool the contents to room temperature and add 50 mL of 50 g/L boric acid in order to complex the excess HF. Digest the sample for a further 90 minutes at 90°C. Transfer the solution to a 100 mL polyethylene flask, make up to volume and mix. Analyze solution by atomic absorption spectrophotometer (A.A.S.).
Cu, Pb, Zn, Co, Ni and Mo	Add 15 mL of concentrated HF, 5 mL of concentrated HCl and 5 mL of 50 vol % $HClO_4$ to 1 g of sample in a 100 mL Teflon beaker. Allow to digest overnight and then heat to dryness on a hot plate. Take up the residue in 10 vol % HCl by gently heating on hot plate. Cool the solution and make up to 50 mL with 10 vol % HCl. Analyze this solution directly by A.A.S..
Ag	Use the same method as described above for stream sediment, soil and till.
F	Use the same method as described above for lake sediment.

Lake and Stream Waters

Zn	Aspirate the sample directly into an air-acetylene flame and analyze by A.A.S..
pH	Determine pH in the field as soon as possible after collection using an Orion specific ion meter with a combination electrode, calibrated using standard buffer solutions.
Heavy metals	The method used is after Davenport (1972). Add 50 mL of sample, 10 mL of buffer solution and 5 mL of 0.002% dithizone solution in benzene to a 125 mL separatory funnel. Stopper and shake vigorously for one minute. After phases have separated, run off and discard aqueous phase and run off benzene phase into a test tube. Estimate the heavy metal content by comparing color against standards of known composition.

Preparation of Buffer Solution

Dissolve 50 g of citric acid (monohydrate) and 8 g of hydroxylamine hydrochloride in about 800 mL of de-ionized water. Add 5 mL of 0.04% thymol blue solution followed by ammonia (sp. gr. 0.90), until a distinct blue color is obtained and the pH is about 9.6. Dilute to 1 L with de-ionized water. Pour into a 2 L separatory funnel and shake with about 25 mL of 0.01% dithizone solution in carbon tetrachloride until free of dithizone-reacting metals. Back-extract excess dithizone by shaking with chloroform.

Note: Benzene is highly toxic and should only be used in a well ventilated area.

APPENDIX B

CODING FORMS FOR FIELD DATA

Standardized coding forms were filled out during sample collection for all phases of the surveys. The use of such forms has many advantages including speed, uniformity of description of samples and sites among various field personnel, completeness and the ability to transfer the data easily to magnetic tape or disk for computer processing. The field data set can be readily merged with the analytical data for statistical analysis. Almost all variables are coded by number rather than by letter as this format is more easily handled by most computer programs.

Some variables have proven significant in data interpretation. For example lake depth was found to correlate strongly with trace element content in many instances and was used in regression analysis to clarify dispersion patterns. Other variables such as "duplicate", "rock type", "soil horizon" and "weathering" can be used to create and compare subsets of data. The UTM coordinates permit data to be plotted rapidly and accurately using a computerized plotting facility.

Reproduced at 50% of actual dimensions in Figures B-1 to B-4 are examples of the coding forms used in the collection of samples of lake sediment and water, stream sediment and water, soil and till, and rock. The forms were developed for general application; more specific sampling programs might require a form designed to provide more detailed observations of some aspects of the sample or site. Most column headings on the forms are self-explanatory but those less apparent are expanded upon as follows:

Column(s)	*Description*
3	This column is reserved on all forms to denote sample type, e.g. lake sediment, rock sample, etc.

Lake Sediment and Water Data Form

35	"VEG" describes the vegetation surrounding the lake such as thickly wooded, barren, bog, etc.
39	"COMPOS" describes composition and textures of sample, e.g. clastic and fine grained, organic ooze, peaty, etc.
41	"DUP & LAYERS" denotes (1) whether the sample is a normal single sample or first or second of a duplicate sample pair and (2) whether or not the sample is layered and, if so, which layer is sampled.
50	This column describes water color, e.g. colorless, yellow or brown.
51	This column describes the relative amount of suspended matter in the water.

Stream Sediment and Water Data Form

38	"PPT STAIN" describes the color of a precipitation stain if present in the sampled material.
40-43	These columns are used to record an estimate of the relative proportions of particle sizes and of organic matter in the sample.

Soil and Till Data Form

50	Denotes absence of, or type of tree cover, e.g. conifers, deciduous, mixed forest.
51	Denotes dominant species present, e.g. spruce, birch, poplar, labrador tea, etc.
52	Describes the intensity of vegetation cover, e.g. open, sparse, well wooded, etc.
57	"CLASSIF" denotes material classification, e.g. undifferentiated glacial material, local till, esker sediment, podzolic, organic, etc.

Rock Data Form

33	"HOMOG" is an estimate of the homogeneity of the outcrop, hence is a measure of the extent to which the sample is representative of the outcrop.
60	"ALTER" describes the type of alteration present (if any) in the sample, e.g. silicification, epidotization, etc.

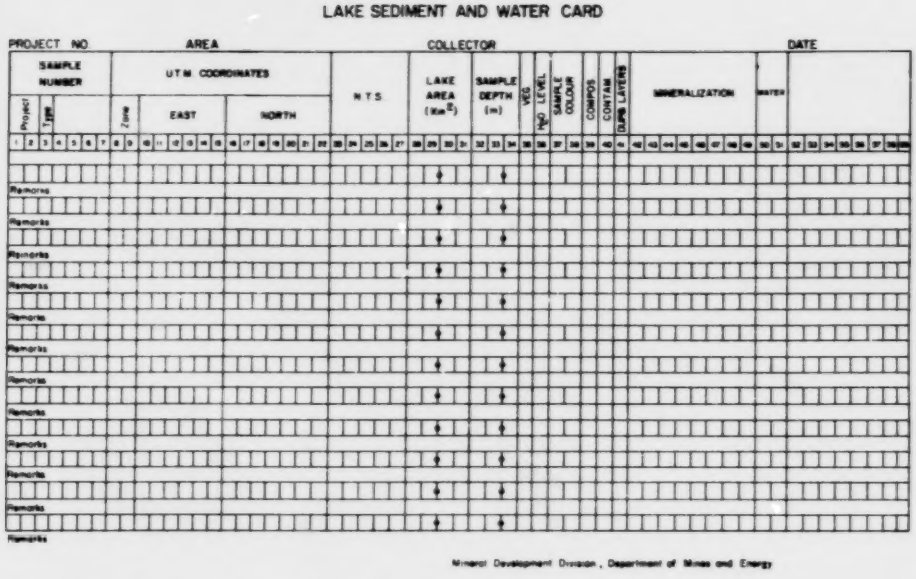


Figure B-1: Field data form for lake sediment and water samples.

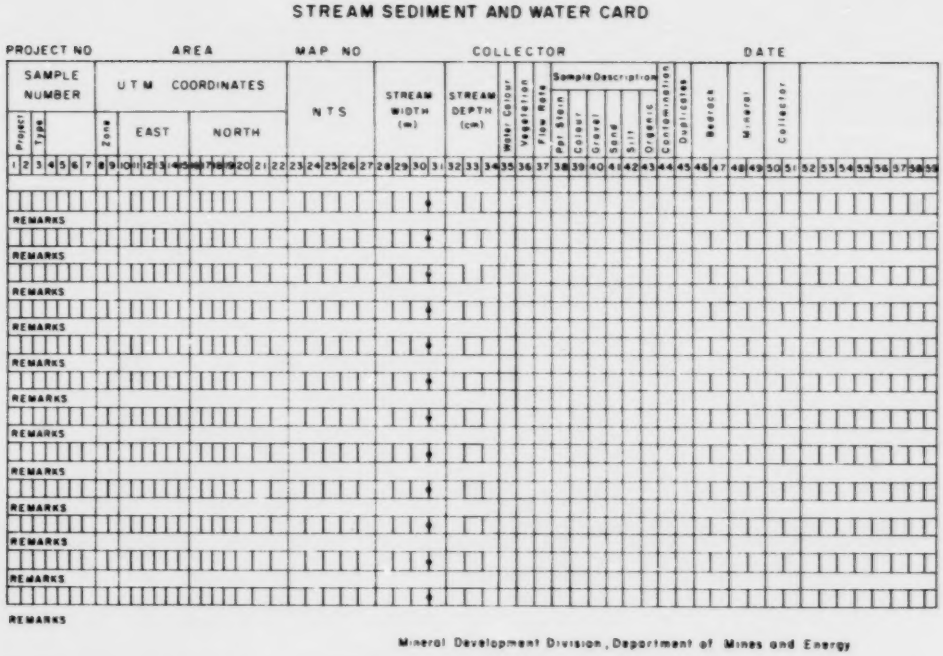


Figure B-2: Field data form for stream sediment and water samples.

Soil and Till Samples - Field Data Card

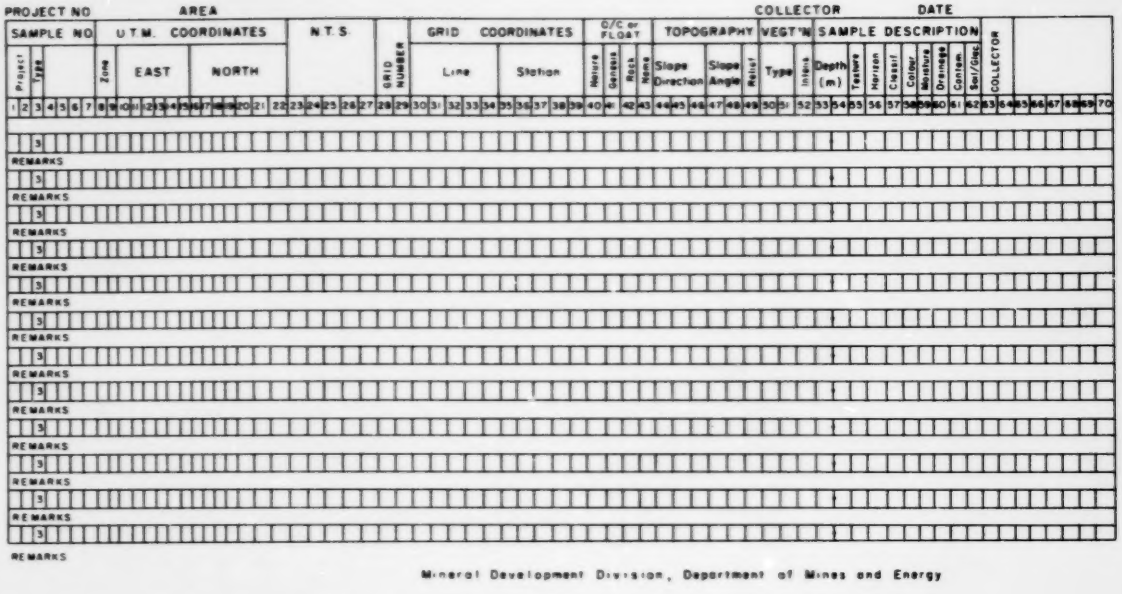


Figure B-3: Field data form for soil and till samples.

ROCK SAMPLE FIELD DATA SHEET

Mineral Development Division
Department of Mines and Energy

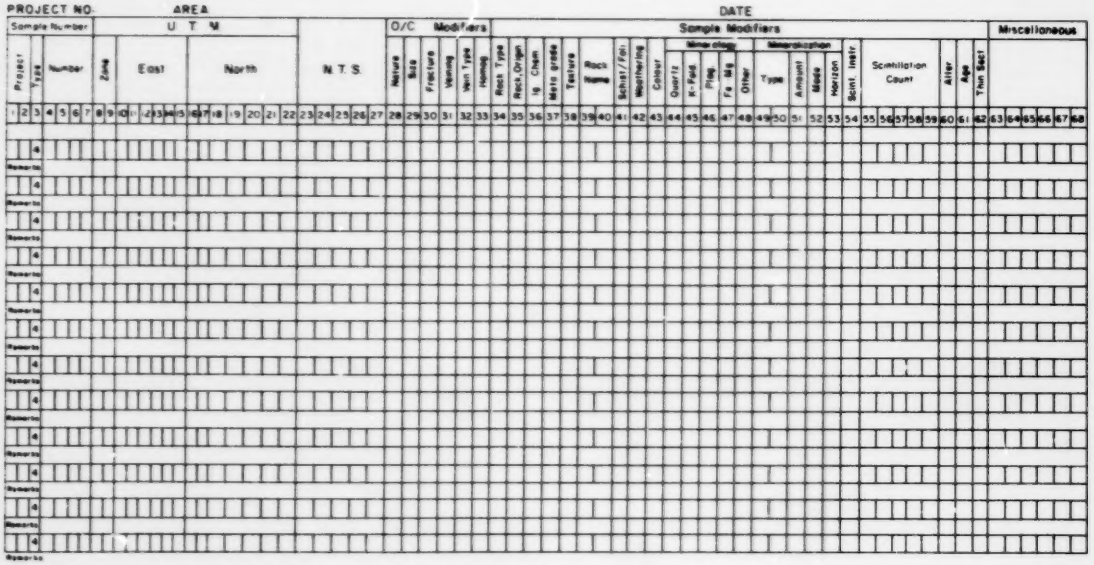
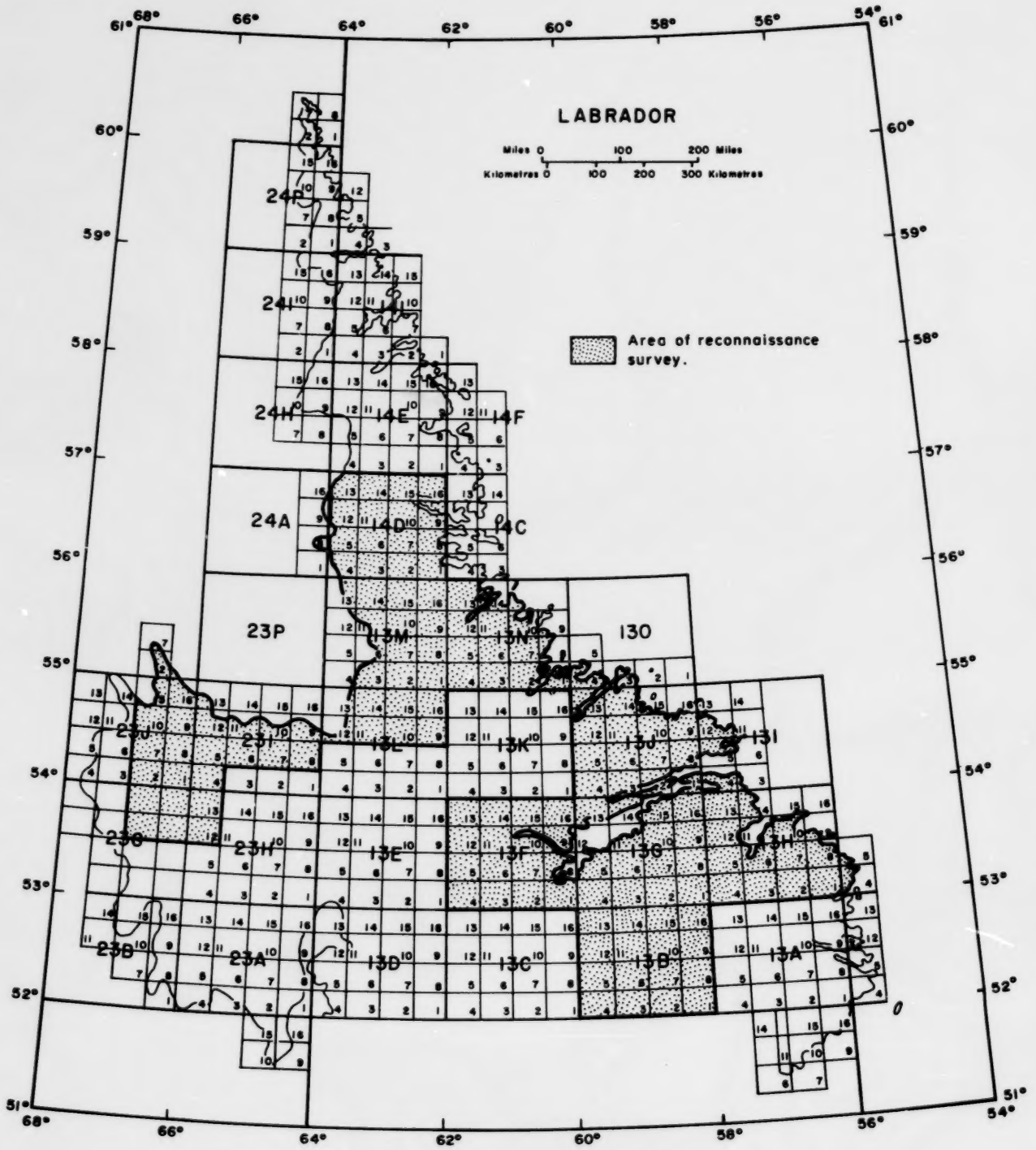


Figure B-4: Field data form for rock samples.


LABRADOR
Miles 0 100 200 Miles
Kilometres 0 100 200 300 Kilometres
Area of reconnaissance survey.
24P
24I
24H
14E
14F
24A
14D
14C
23P
13M
13N
13O
23J
23I
13L
13K
13J
13I
23O
23H
13E
13F
13G
13H
23B
23A
13D
13C
13B
13A
68°
66°
64°
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60°
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